— 1984

ALFALFA

Location	Baseline	Source
New Mexico, Arizona	0.96-1.93*VPD	Abdul et. al. (1985)
Nebraska, Kansas, Minnesota	0.51-1.92*VPD	Idso (1982)
	maximum ΔT=2.0 C	

BARLEY

Arizona	sunlit, pre-heading	2.01-2.25 *VPD	Idso (1982)
Arizona	sunlit,post-heading	1.72-1.23*VPD	Idso (1982)

Beets

Arizona	5.16-2.30 *VPD	Idso (1982)

Chard

Arizona	2.46-1.88*VPD	Idso (1982)

Corn

Arizona	3.11-1.97*VPD	Idso (1982)
Nebraska	2.67-2.059*VPD	Gardner (unpublished)

Cotton

California	2.06-1.73*VPD	Howell et. al. (1984)
California	1.00-2.09*VPD	Reginato (1982)
California (3ft. beds, single rows)	1.68-1.82*VPD	Howell et al. (1982)
California (3 ft. beds double rows,)	2.08-1.80*VPD	Howell et al. (1982)
California (3 ft. beds, single rows)	2.06-1.73*VPD	Howell et al. (1982)
Arizona	1.49-2.09*VPD	Idso (1982)
Arizona	1.71-1.90*VPD	Pinter et al. (1982)
Arizona	maximum ΔT= 3	Pinter et al. (1983)
Arizona	2.0-2.24*VPD	Reginato (1983)
Texas (50% ground cover)	2.20-0.98*VPD	Wanjura et al. (1984)
	maximum ΔT = 5	Wanjura et al. (1984)

Cowpeas

Arizona	1.32--1.84*VPD	Idso (1982)

Cucumber

Arizona	sunlit	4.88-2.52*VPD	Idso (1982)
Arizona	shaded	-1.28-2.14*VPD	Idso (1982)

Fig Tree

Arizona		4.22-1.77*VPD	Idso (1982)

Green Beans

Arizona	sunlit	2.91-2.35*VPD	Idso (1982)
Arizona	shaded	-1.57-2.11	Idso (1982)

Guayule

Arizona		1.87-1.75*VPD	Idso (1982)

Kohlrabi

Arizona		2.01-2.17*VPD	Idso (1982)

Lettuce, leaf

Arizona		4.18-2.96 *VPD	Idso (1982)

Peas

Arizona		2.74-2.13*VPD	Idso (1982)

Potato

Arizona		1.17-1.83*VPD	Idso (1982)

Pumpkin

Arizona	sunlit	0.95-1.93*VPD	Idso (1982)
Arizona	shaded	-1.32-2.10*VPD	Idso (1982)

Rutabaga

Arizona	sunlit	3.75-2.66*VPD	Idso (1982)
Arizona	shaded	-0.50-2.51*VPD	Idso (1982)

Soybean

Kansas,Nebraska, North Dakota		1.44-1.34*VPD	Idso (1982)
		maximum ΔT = 3.0 C	

Squash,hubbard

Arizona	sunlit	6.91-3.09*VPD	Idso (1982)
Arizona	shaded	2.12-2.83*VPD	Idso (1982)

Squash, zuccini

Arizona	2.00-1.88*VPD maximum $\Delta T = 4.0$	Idso	(1982)

Sugar Beet

Arizona	2.50-1.92*VPD	Idso	(1982)

Sunflower

Kansas	0.66-1.95*VPD	Idso	(1982)

Tomato

Arizona	2.86-1.96*VPD	Idso	(1982)

Turf Grass

Kentucky Blugrass	7.7-2.2*VPD maximum $\Delta T=12.75$	(Throssel, Univ. of Georgia, unpublished)

Turnip

Arizona	1.94-2.26*VPD	Idso	(1982)

Water lily

Arizona	8.99-1.93*VPD	Idso	(1982)

Wheat, produra

Arizona	pre-heading	3.38-3.25*VPD	Idso	(1982)
Arizona	post-heading	2.88-2.11*VPD	Idso	(1982)

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To: S.C. DeSutter Copy : R. Felice, D Cooper

From: B.R. Gardner

Subject : New Baselines

This memo provides a listing of the code to be used for the given crops and the limitations attached to each.

All indices are calculated as [(Diff-min)/(min-max)]*100, rounded off, ie, no decimal points. The scale thus runs (theoretically) between 0 and 100. You may wish to change this to have a scale between 0 and 10, with 1 decimal point. That's your choice. My preference is for the 0 to 100 scale since I can relate the scale to percent stress more easily.

The criteria for selecting the VPD restrictions are based on statistical theory and a theoretical analysis of each baseline. It was assumed that sensor calibration errors (at equilibrium) will remain constant during use. Any existing sensor calibration problems should have the main effect of causing two different Scheduler units to produce slightly different indices, but would provide consistent results for a given unit. This is the best that can be expected in the "real world". As long as we meet our specs, this effect should be minor. The major concern is what happens to the index with "random error", that is , errors produced as a result of equilibration problems or sampling error. A "worst case" estimate of 1 C (1.8 F) was assumed for these types of errors. In addition, it was assumed that differentiating between 0.1 differences in the index was sufficient, i.e, the accuracy of the index is within plus or minus 0.1 on the old scale. Further, it was assumed that a "typical user" would probably collect between 80 and 100 samples (although 180 samples can be collected in only a minute). This means that the maximum effect a 1 C random error can have on this index is plus or minus 0.2 on the old scale (appendix 1). The SAS code used to test each model and their errors is given in appendix 2. A plot of each model's upper and lower baselines , with their respective index errors for a 1 C error in (Tc-Ta) is given in appendix 3

VPD is the vapor pressure deficit
VPG is the vapor pressure gradient, using the procedure used for the old models
VPD=(1-rh/100)*0.61078*exp(17.2693882*Ta/(Ta+237.3))
E1= 0.61078*exp(17.2693882*Ta/(Ta+237.3))
E2=0.61078*exp(17.2693882*(a+Ta)/(Ta+a+237.3))
VPG=E1-E2

Turf Index
a=7 b= -2.5
min = 7-2.5*VPD
if VPD LT 3.0 then min=-0.5
if VPD LT 3.0 then max=11+3*VPD
if VPD GE 3.0 then max=20+min

there are no other restrictions on this index
this index is very versitile and would be the first index of choice for any crop on which a baseline has not been developed but on which it is desired to do a test, i.e. , an "all purpose" index. There is a strong theoretical reason for this.

Cotton Index
a=1.76 b = -1.93

min = 1.76-1.93*VPD
max= 1.76-1.93*VPG

this index should not be calculated **below** a VPD of 1.0

Corn index

a=2.67 b = -2.059

min= 2.67-2.059*VPD
max = 2.67-2.059*VPG

this index should not be calculated **below** a VPD of 1.5

Grapes Index

a=3.5 b= -1.657

min= 3.5 -1.675*VPD
max= 3.5-1.657*VPG

if VPD LT 2.0 then min = 0.15

there are no restrictions on this index

cauliflower index

a= -0.5 b= -1.5
min = -0.5 -1.5*VPD
max = 2.5-0.5*VPD ; note this is VPD, not VPG !

this index should not be used **above** a VPD of 2.0, except in the case of the research instrument for Jon Anderson

Celery index

a = -0.5 b= -1.5

min= -0.5-1.5*VPD
max= 3.0-0.5*VPD , this is VPD , not VPG

this index should not be used **above** a VPD of 2.0, except in the case of Jon Anderson's research instrument

Lettuce index

a= 0.5 b = -1.5

min = 0.5-1.5*VPD
max=4-0.5*VPD , this is VPD, not VPG

this index should not be used **above** a VPD of 2.0 , except in the case of Jon Anderson's reseach instrument

Sugar Beets

a = 2.50 b = -1.92

min = 2.50 - 1.92*VPD
max = 2.50 - 1.92 *VPG

this index should not be used **below** a VPD of 1.5

Wheat model

a = -3 b = -1.5

min = -3 -1.5*VPD
max= 5

this index should not be used **below** a VPD of 1.5

Alfalfa model

a = 2.04 b = -2.02

min = 2.04 - 2.02*VPD
max= 2.04 -2.02 *VPG

this index should not be used **below** a VPD of 1.5

APPENDIX I

REPLICATIONS REQUIRED FOR MEASURING CWSI TO DESIRED SPECIFICATIONS

The quality of decisions possible with the Scheduler depends on the reliability of the index provided. The reliability of a given index by the Scheduler is a direct function of the number of samples taken ,the standard deviation of the samples and the degree of confidence desired by a user. Statistical theory can be use to directly estimate the number of samples required . Understanding the following table is essential:

Standard Deviation of CWSI (0-1 scale)	Critical Diff.	# Reps P(0.05)	#Reps P(0.01)
0.05	0.02	136	264
0.10	0.02	544	1058
0.20	0.02	2178	4232
0.30	0.02	4900	9522
0.40	0.02	8712	16,900
0.50	0.02	13612	26,450
0.05	0.05	22	42
0.10	0.05	87	169
0.20	0.05	350	677
0.30	0.05	785	1523
0.40	0.05	1393	2700
0.50	0.05	2178	4232
0.05	0.10	5	11
0.10	0.10	22	42
0.20	0.10	87	170
0.30	0.10	196	380
0.40	0.10	348	677
0.50	0.10	550	1100

Suppose a user sampled a turf area to determine the stress index. He found he had an average of 0.20, with an expected standard deviation of 0.1 (due to sampling and instrument error, etc.). What is the correct interpretation of these results. The simplistic (but incorrect) interpretation would be to assume that the correct average is somewhere between 0.1 and 0.3. The correct interpretation requires that two additional questions be asked: how many samples and what degree of confidence? If 550 samples were collected, and the user accepted a 5% probability of error, then it would be correct to say that the true average is between 0.18 and 0.22.

APPENDIX II

```
DATA TEST;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
PROC MEANS;
TITLE 'CHARACTERISTICS OF THE DATA SET USED TO TEST THE CWSI MODELS';
***************CALCULATE THE TURF MODEL*******************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
A=7;B=-2.5;
MIN=A+B*VPD;
IF VPD LT 3 THEN MIN=-0.5;
IF VPD GE 3 THEN MAX=20+MIN;
IF VPD LT 3 THEN MAX=11+3*VPD;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='TURF INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='TURF INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='TURF INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--TURF GRASS';
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE'TURF GRASS INDEX';
***************************END OF TURF MODEL***************;
***************CALCULATE THE COTTON MODEL*******************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
A=1.76;B=-1.93;
MIN=A+B*VPD;
F1=0.61078*EXP(17.2693882*TA/(TA+237.3));
F2=0.61078*EXP(17.2693882*(TA+A)/(TA+A+237.3));
VPG=F1-F2;
MAX=A+B*VPG;
IF VPD LT 2 THEN MIN=-2.0;
IF VPD LT 2 THEN MAX=2.8;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='COTTON INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='COTTON INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='COTTON INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--COTTON ';
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE 'COTTON INDEX';
***************************END OF COTTON MODEL***************;
***************CALCULATE THE CORN MODEL*******************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
A=2.67;B=-2.059;
MIN=A+B*VPD;
F1=0.61078*EXP(17.2693882*TA/(TA+237.3));
F2=0.61078*EXP(17.2693882*(TA+A)/(TA+A+237.3));
VPG=F1-F2;
MAX=A+B*VPG;
```

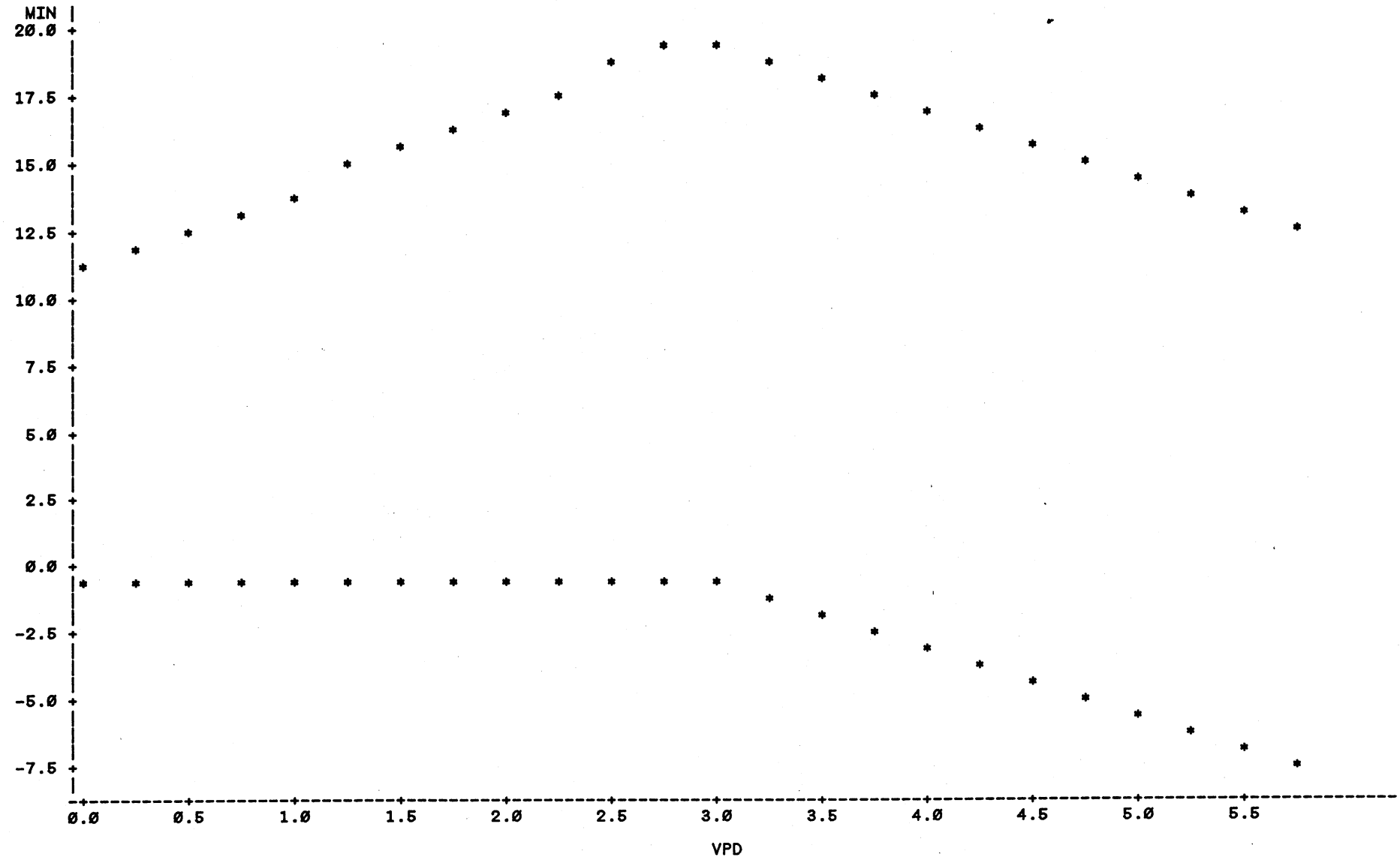
```
IF VPD LT 1.5 THEN MIN=0;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='CORN INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='CORN INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='CORN INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--CORN ';
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE 'CORN INDEX';
**************************END OF CORN MODEL***************;
***************CALCULATE THE GRAPES MODEL*****************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
A=3.5;B=-1.675;
MIN=A+B*VPD;
F1=0.61078*EXP(17.2693882*TA/(TA+237.3));
F2=0.61078*EXP(17.2693882*(TA+A)/(TA+A+237.3));
VPG=F1-F2;
MAX=A+B*VPG;
IF VPD LT 2 THEN MIN= 0.15;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='GRAPES INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='GRAPES INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='GRAPES INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--GRAPES ';
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE 'GRAPE INDEX';
**************************END OF GRAPES MODEL***************;
***************CALCULATE THE CAULIF MODEL*****************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
A=-0.5;B=-1.5;
MIN=A+B*VPD;
MAX=2.5-0.5*VPD;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='CAULIF. INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='CAULIF INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='CAULIF INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--CAULIF';
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE 'CAULIFLOWER INDEX';
**************************END OF CAULIF. MODEL***************;
```

```
**************CALCULATE THE CELERY MODEL*****************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
A=-0.5;B=-1.5;
MIN=A+B*VPD;
MAX=3-0.5*VPD;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='GRAPES INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='GRAPES INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='CELERY INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--CELERY';
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE 'CELERY INDEX';
**************************END OF CELERY MODEL***************;
**************CALCULATE THE LETTUCE MODEL*****************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
A=0.5;B=-1.5;
MIN=A+B*VPD;
MAX=4-0.5*VPD;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='GRAPES INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='GRAPES INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='LETTUCE INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--LETTUCE';
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE 'LETTUCE INDEX';
**************************END OF LETTUCE MODEL***************;
**************CALCULATE THE SUGAR BEETS MODEL*****************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
A=2.50;B=-1.92;
MIN=A+B*VPD;
F1=0.61078*EXP(17.2693882*TA/(TA+237.3));
F2=0.61078*EXP(17.2693882*(TA+A)/(TA+A+237.3));
VPG=F1-F2;
MAX=A+B*VPG;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='SUGAR BEETS INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='SUGAR BEETS INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='SUGAR BEETS INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--SUGAR BEETS';
```

```
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE 'SUGAR BEET INDEX';
**************************END OF SUGAR BEETS MODEL***************;
***************CALCULATE THE WHEAT MODEL*******************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
IF VPD LT 2 THEN DO;A=2;B=-4.0;END;
IF VPD GE 2 THEN DO;A=-3;B=-1.5;END;
MIN=A+B*VPD;
F1=0.61078*EXP(17.2693882*TA/(TA+237.3));
F2=0.61078*EXP(17.2693882*(TA+A)/(TA+A+237.3));
VPG=F1-F2;
MAX= 5;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='WHEAT INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='WHEAT INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='WHEAT INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--WHEAT';
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE 'WHEAT INDEX';
**************************END OF WHEAT MODEL***************;
***************CALCULATE THE ALFALFA MODEL*****************;
DATA ONE;INFILE TEST1;
INPUT RAD TA TC DIFF VPD;
DIFF=TC-TA;
A=2.04;B=-2.02;
MIN=A+B*VPD;
IF VPD LT 1 THEN MIN=0;
F1=0.61078*EXP(17.2693882*TA/(TA+237.3));
F2=0.61078*EXP(17.2693882*(TA+A)/(TA+A+237.3));
VPG=F1-F2;
MAX= A+B*VPG;
I1=(DIFF-MIN)/(MAX-MIN);
LABEL I1='ALFALFA INDEX';
AI1=((DIFF-1)-MIN)/(MAX-MIN);
LABEL AI1='ALFALFA INDEX -1 C ERROR IN DIFF';
BI1=((DIFF+1)-MIN)/(MAX-MIN);
ERROR1=(AI1-I1);
ERROR2=(BI1-I1);
LABEL ERROR1='ERROR IN CWSI WITH -1 ERROR';
LABEL ERROR2='ERROR IN CWSI WITH +1 ERROR';
LABEL BI1='ALFALFA INDEX +1 C ERROR IN DIFF';
TITLE'ERROR IN CWSI--ALFALFA';
TITLE2'WITH 1 C ERROR IN (TC-TA)';
PROC PLOT;PLOT  ERROR2*VPD='*';
PROC PLOT;PLOT MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE'ALFALFA INDEX';
**************************END OF ALFALFA MODEL***************;
```

APPENDIX III

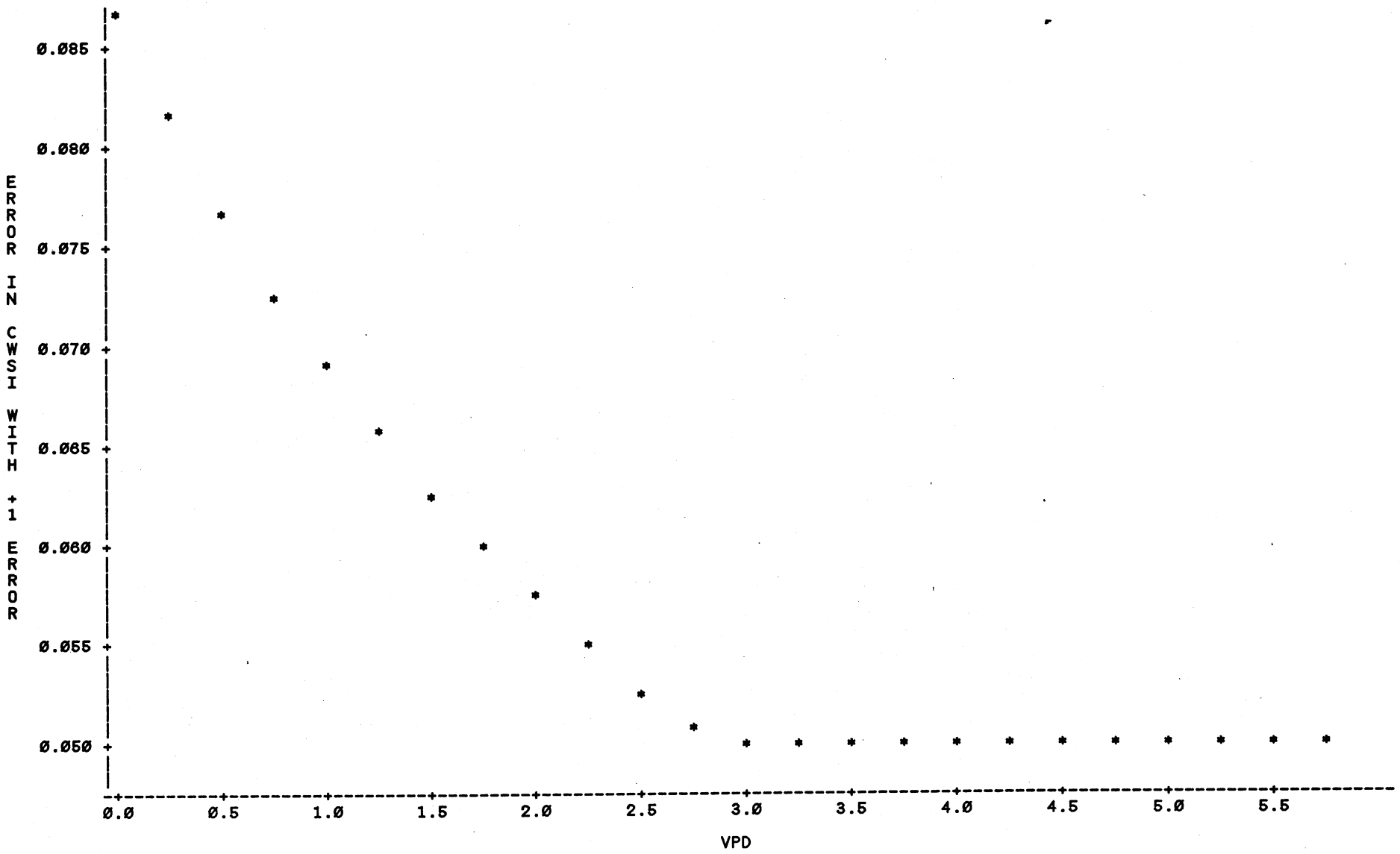
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *



NOTE: 3184 OBS HIDDEN

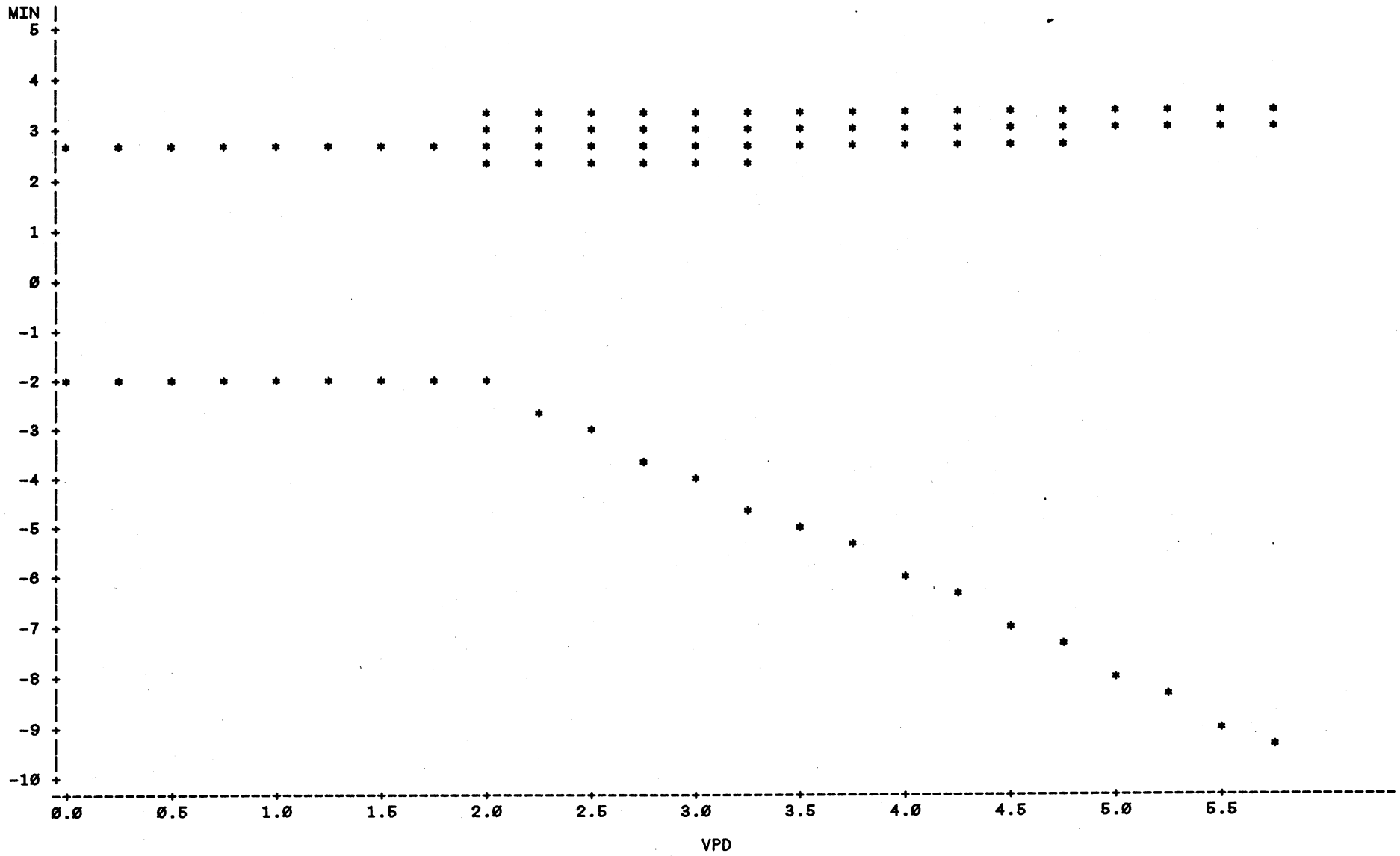
ERROR IN CWSI--TURF GRASS
WITH 1 C ERROR IN (TC-TA)

PLOT OF ERROR2*VPD SYMBOL USED IS *



NOTE: 1592 OBS HIDDEN

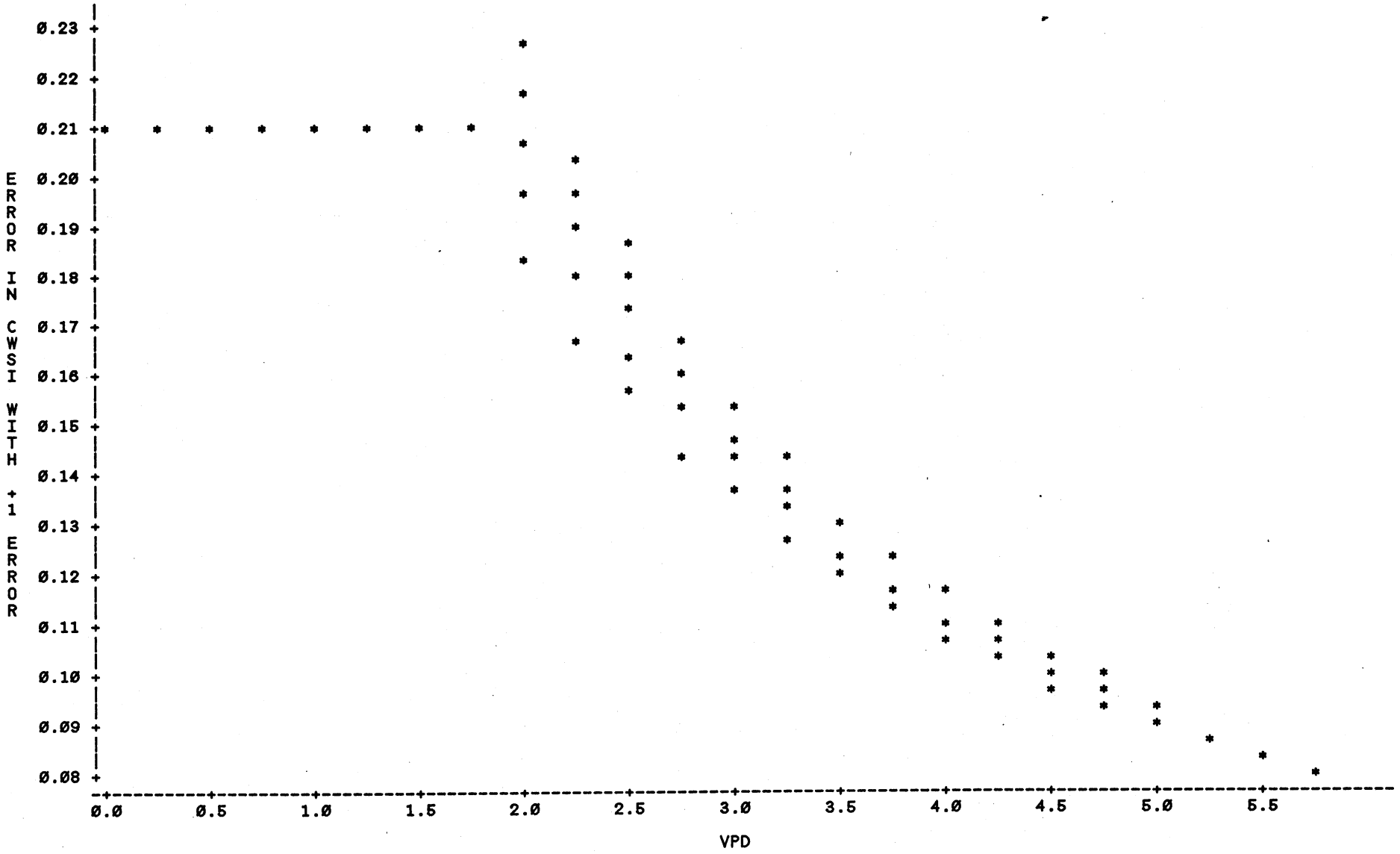
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *



NOTE: 3150 OBS HIDDEN

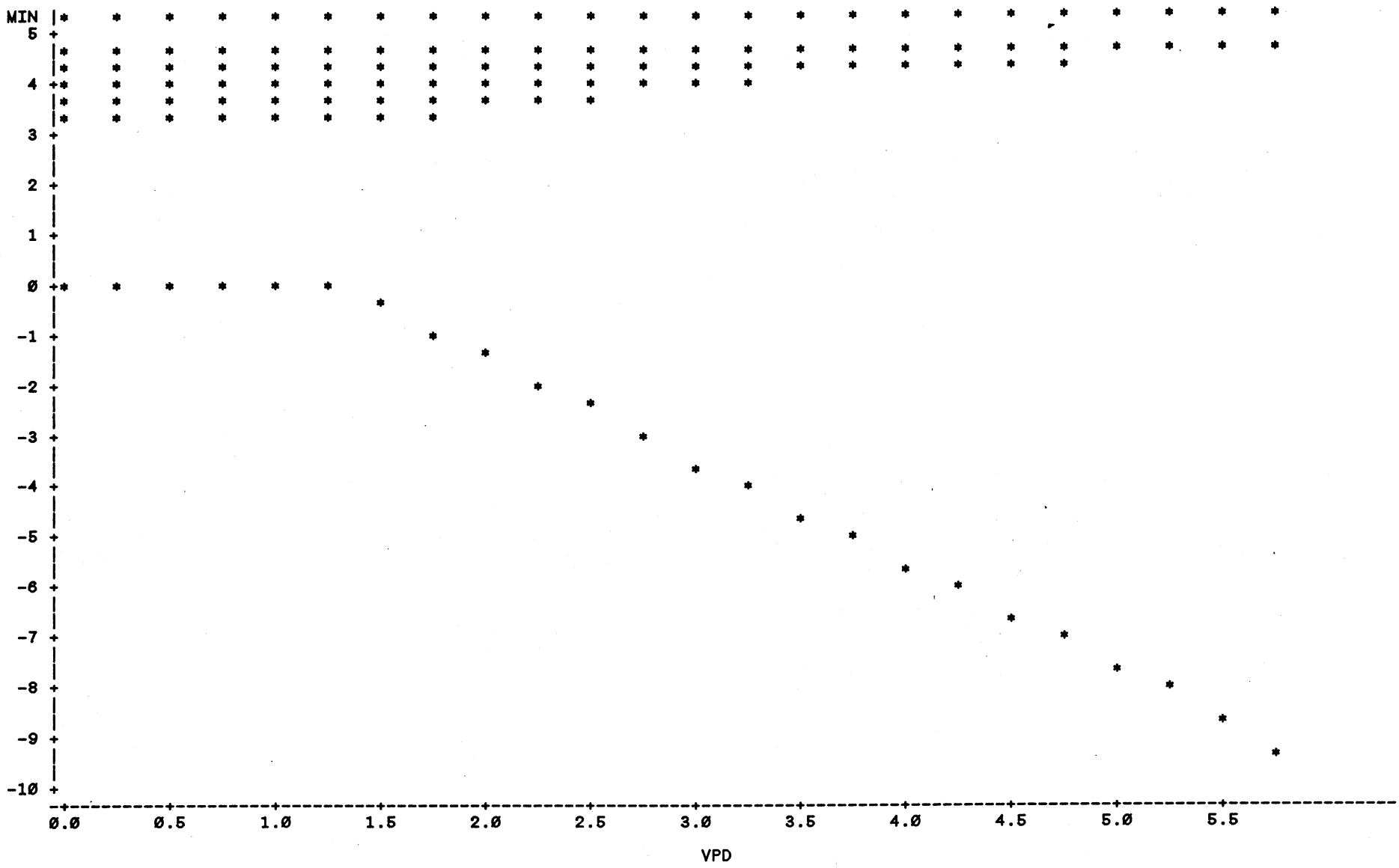
ERROR IN CWSI--COTTON
WITH 1 C ERROR IN (TC-TA)

PLOT OF ERROR2*VPD SYMBOL USED IS *



NOTE: 1558 OBS HIDDEN

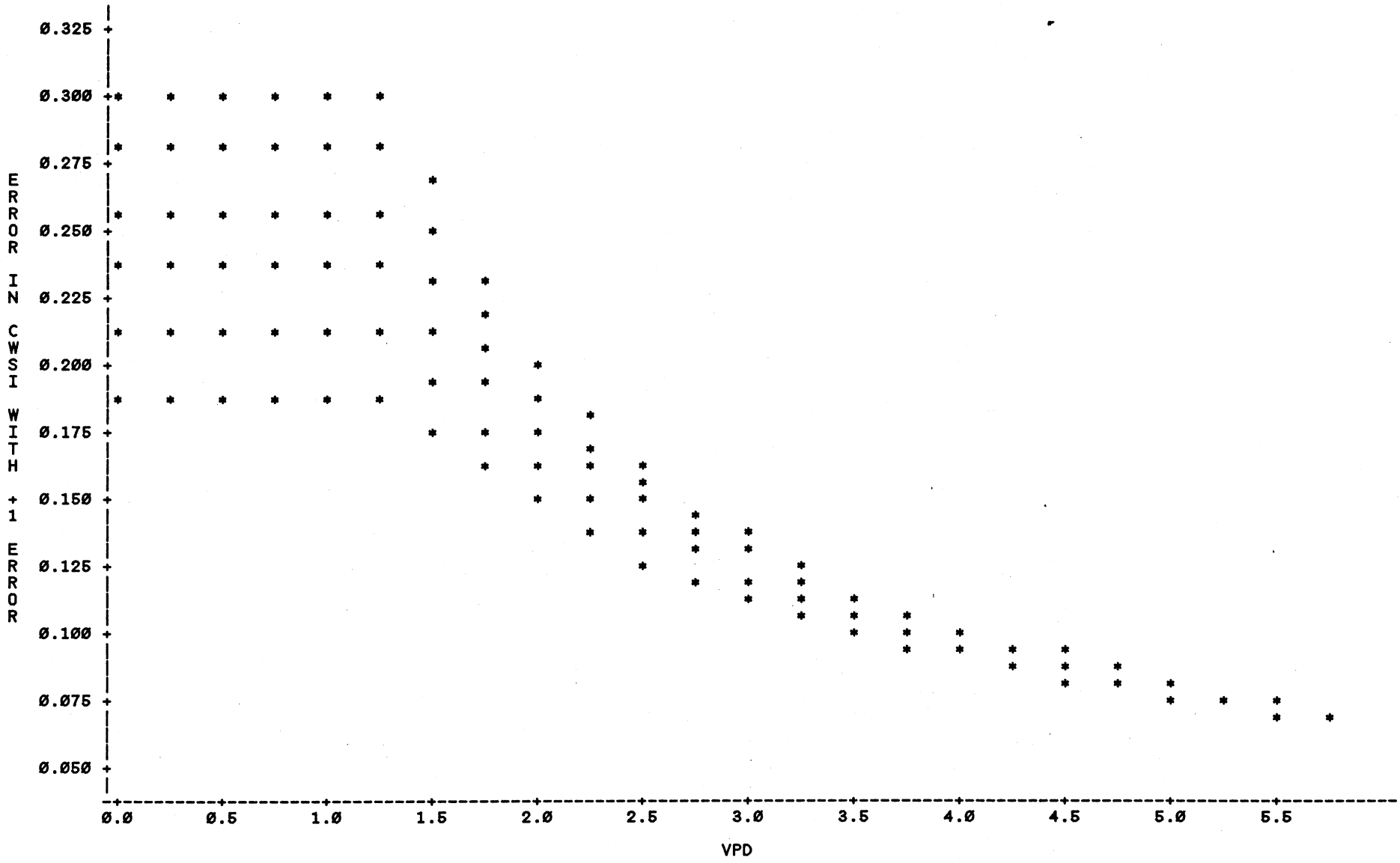
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *



NOTE: 3107 OBS HIDDEN

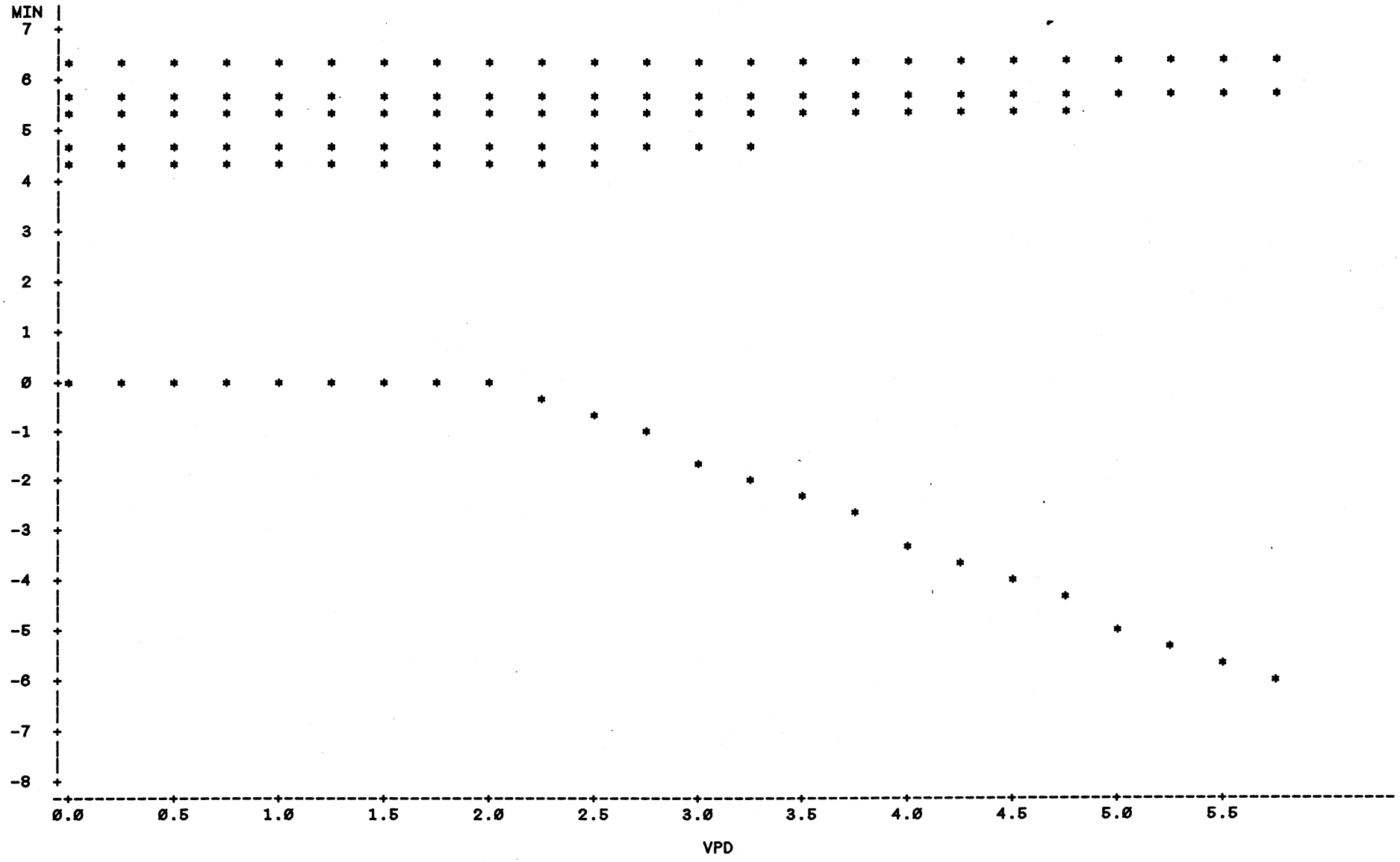
ERROR IN CWSI--CORN
WITH 1 C ERROR IN (TC-TA)

PLOT OF ERROR2*VPD SYMBOL USED IS *



NOTE: 1520 OBS HIDDEN

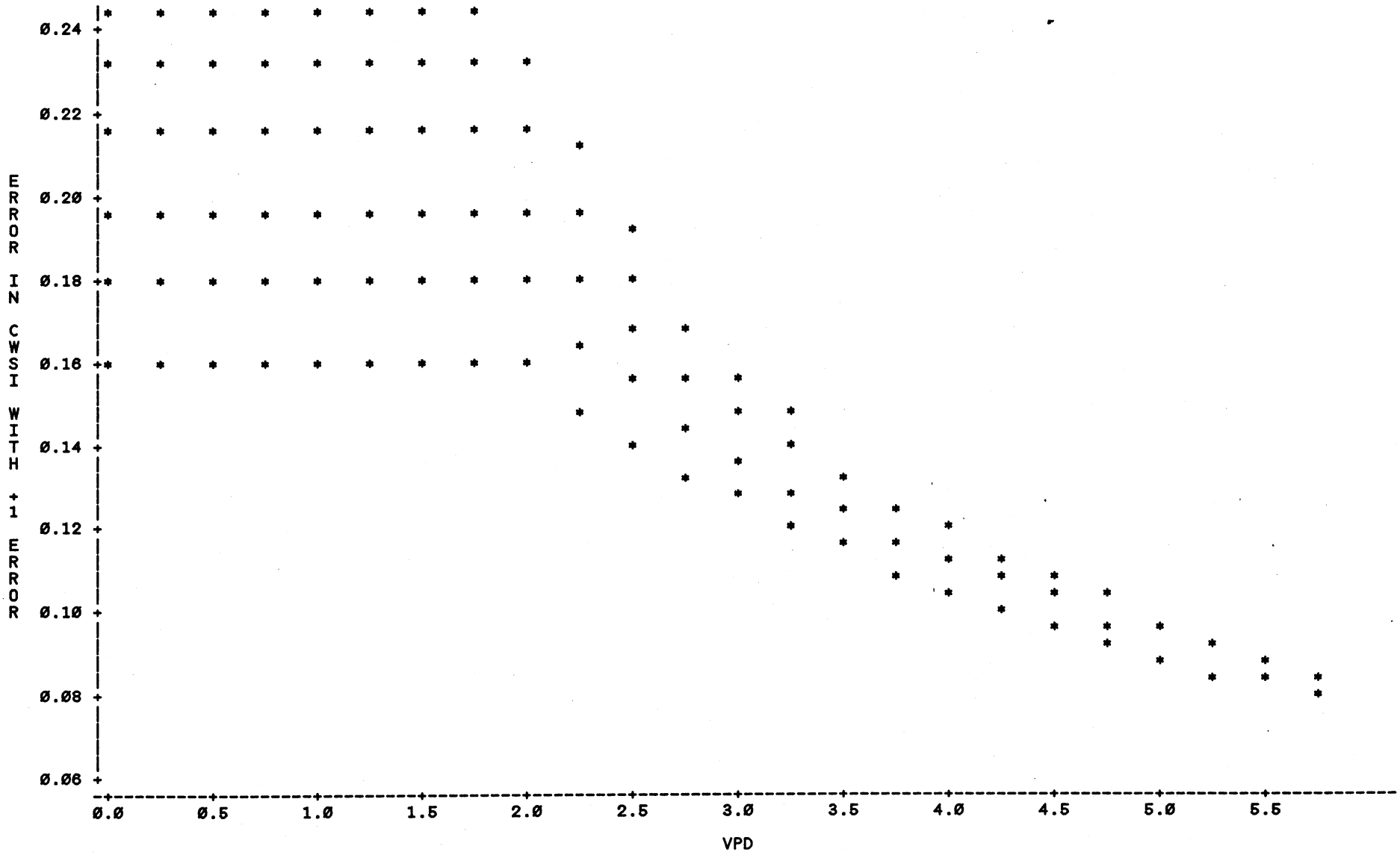
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *



NOTE: 3115 OBS HIDDEN

ERROR IN CWSI--GRAPES
WITH 1 C ERROR IN (TC-TA)

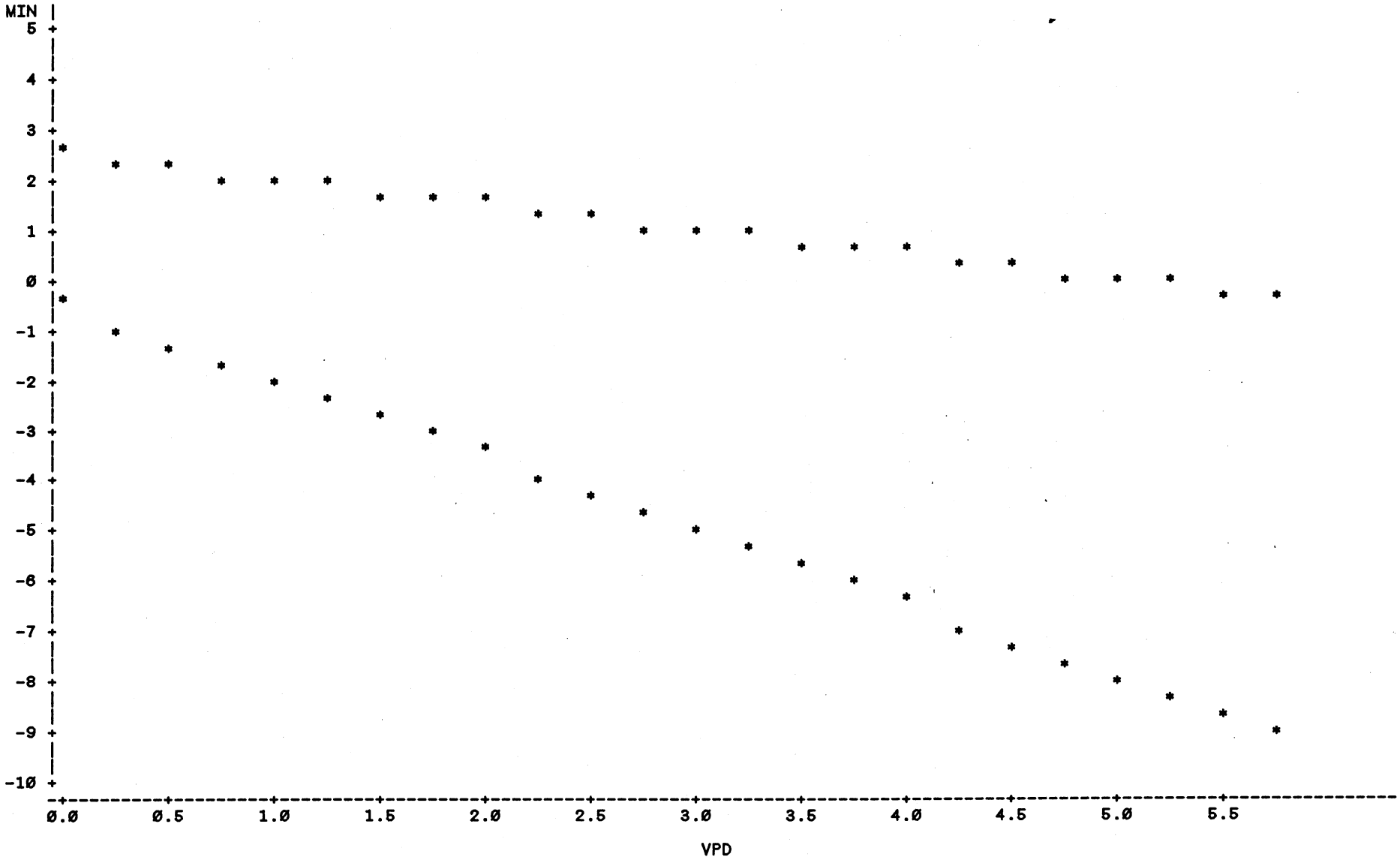
PLOT OF ERROR2*VPD SYMBOL USED IS *



NOTE: 1515 OBS HIDDEN

CAULIFLOWER INDEX

PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *

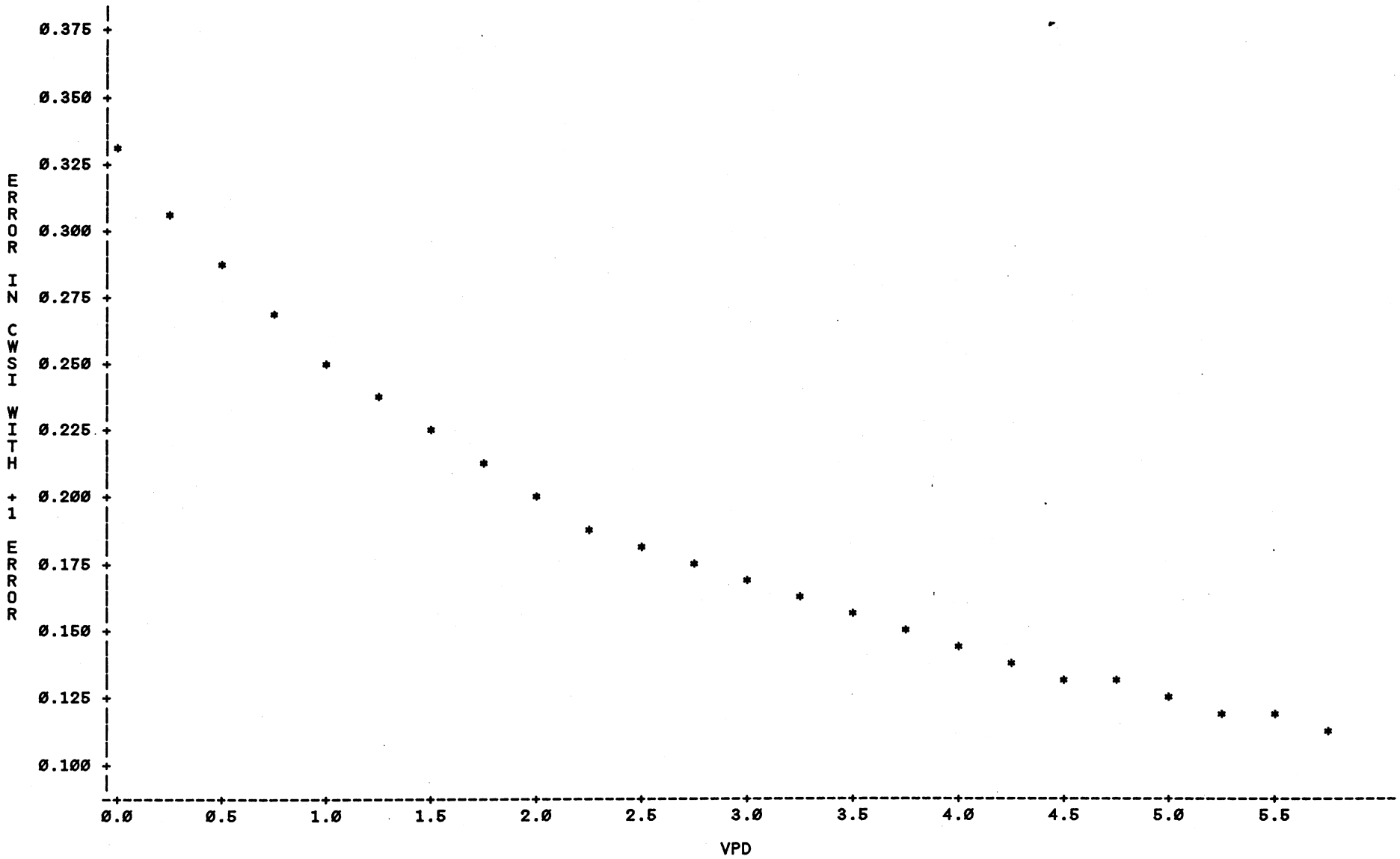


NOTE: 3184 OBS HIDDEN

ERROR IN CWSI--CAULIF
WITH 1 C ERROR IN (TC-TA)

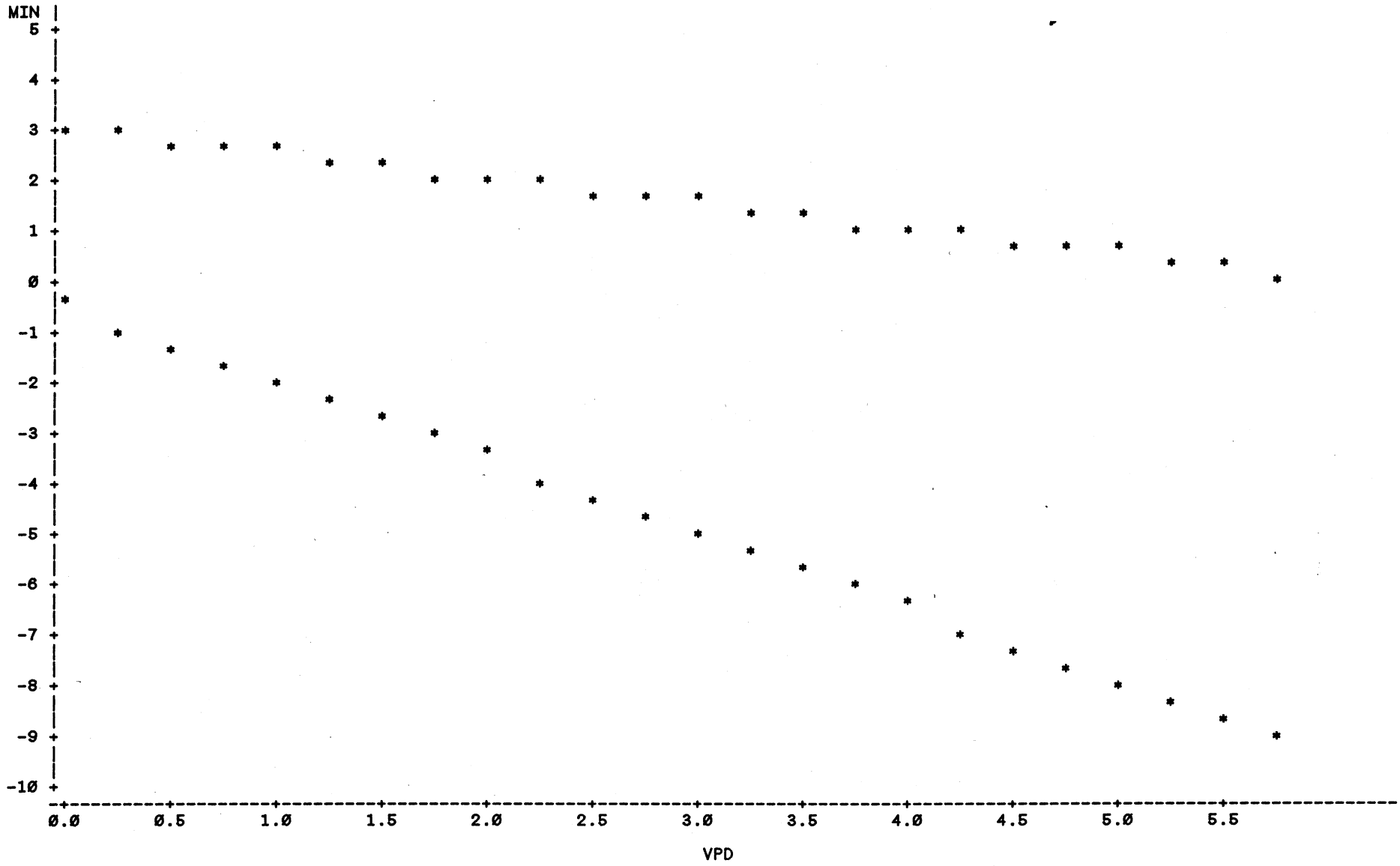
22:30 MONDAY, NOVEMBER 17, 1986 10

PLOT OF ERROR2*VPD SYMBOL USED IS *



NOTE: 1592 OBS HIDDEN

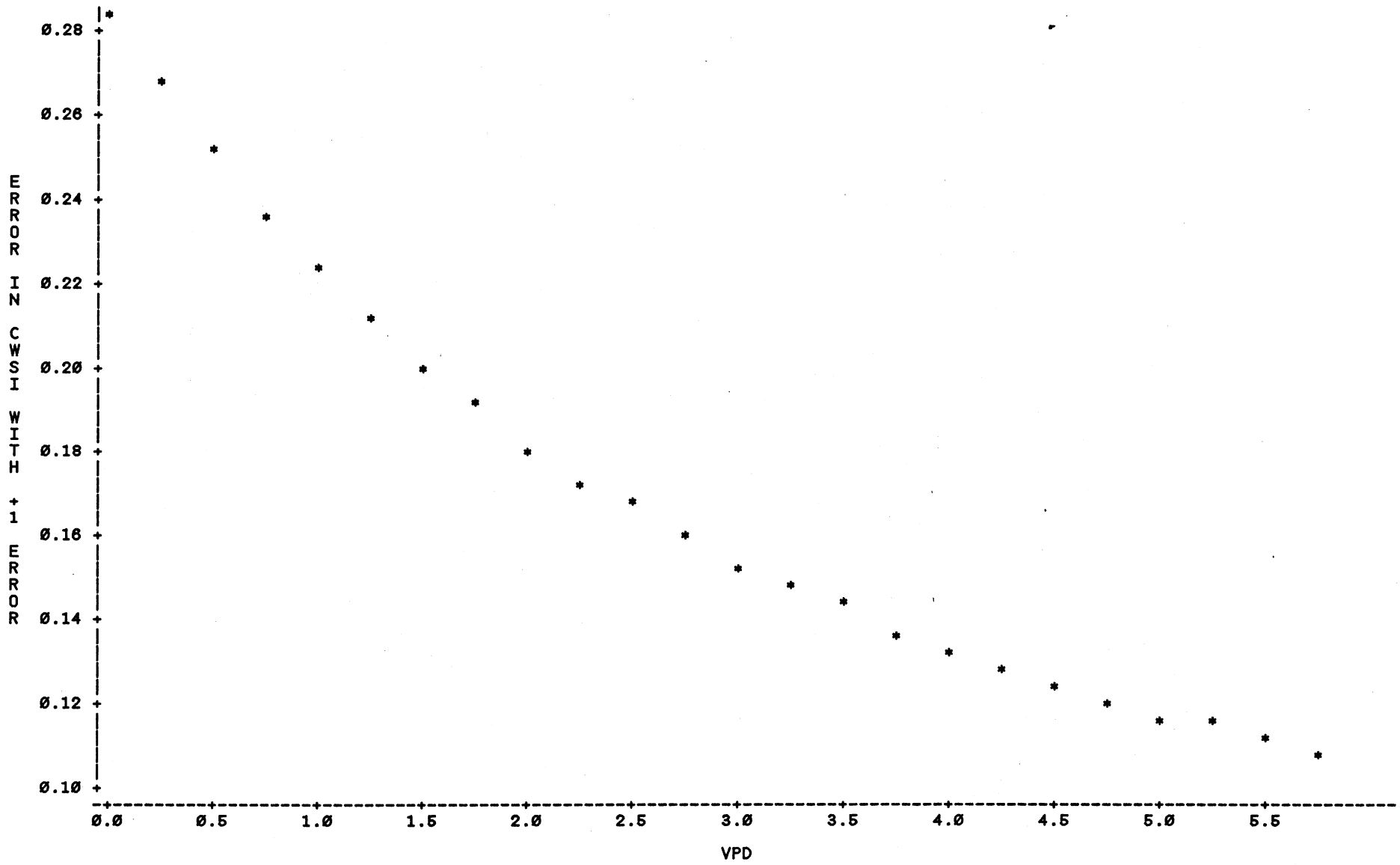
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *



NOTE: 3184 OBS HIDDEN

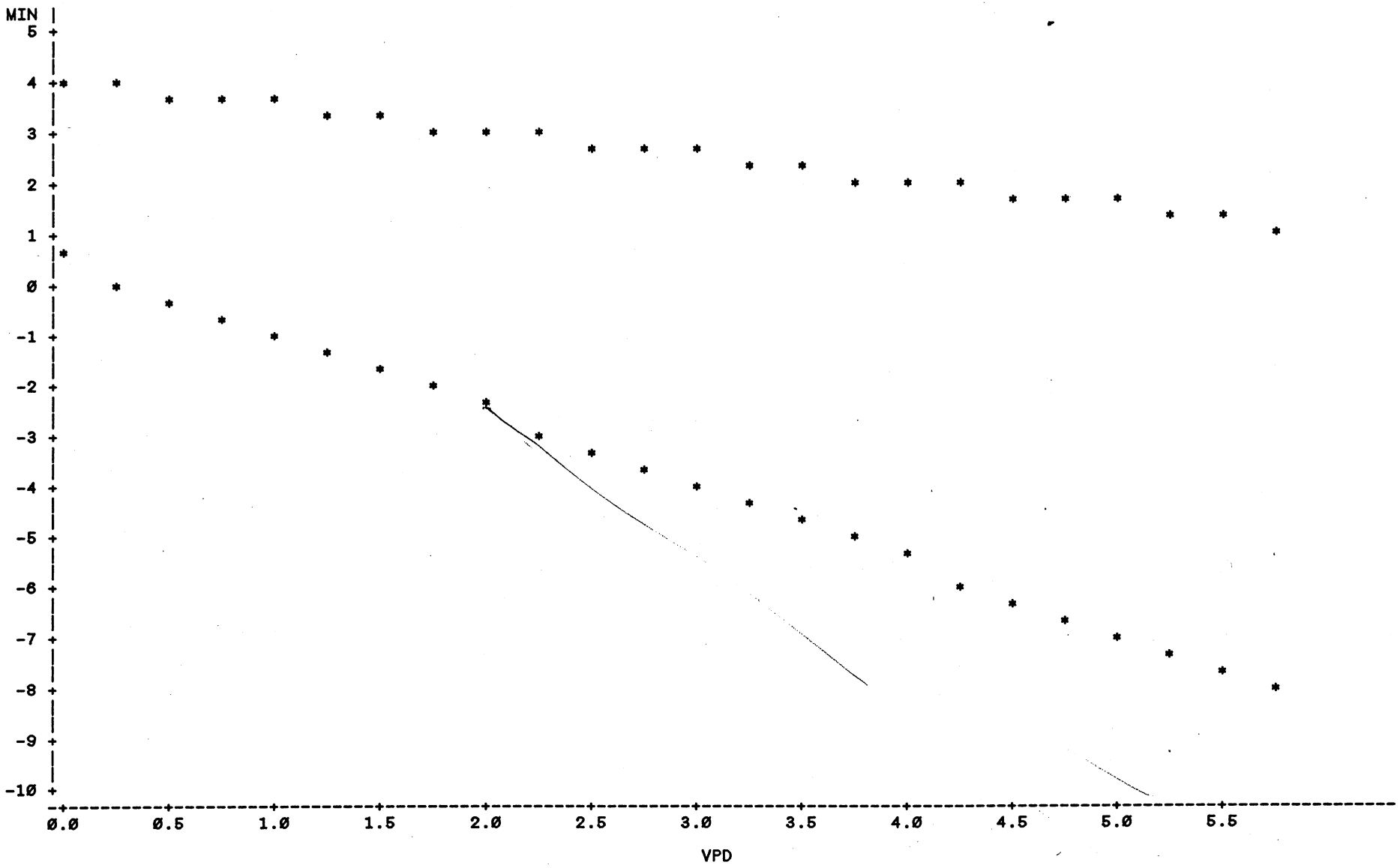
ERROR IN CWSI--CELERY
WITH 1 C ERROR IN (TC-TA)

PLOT OF ERROR2*VPD SYMBOL USED IS *



NOTE: 1592 OBS HIDDEN

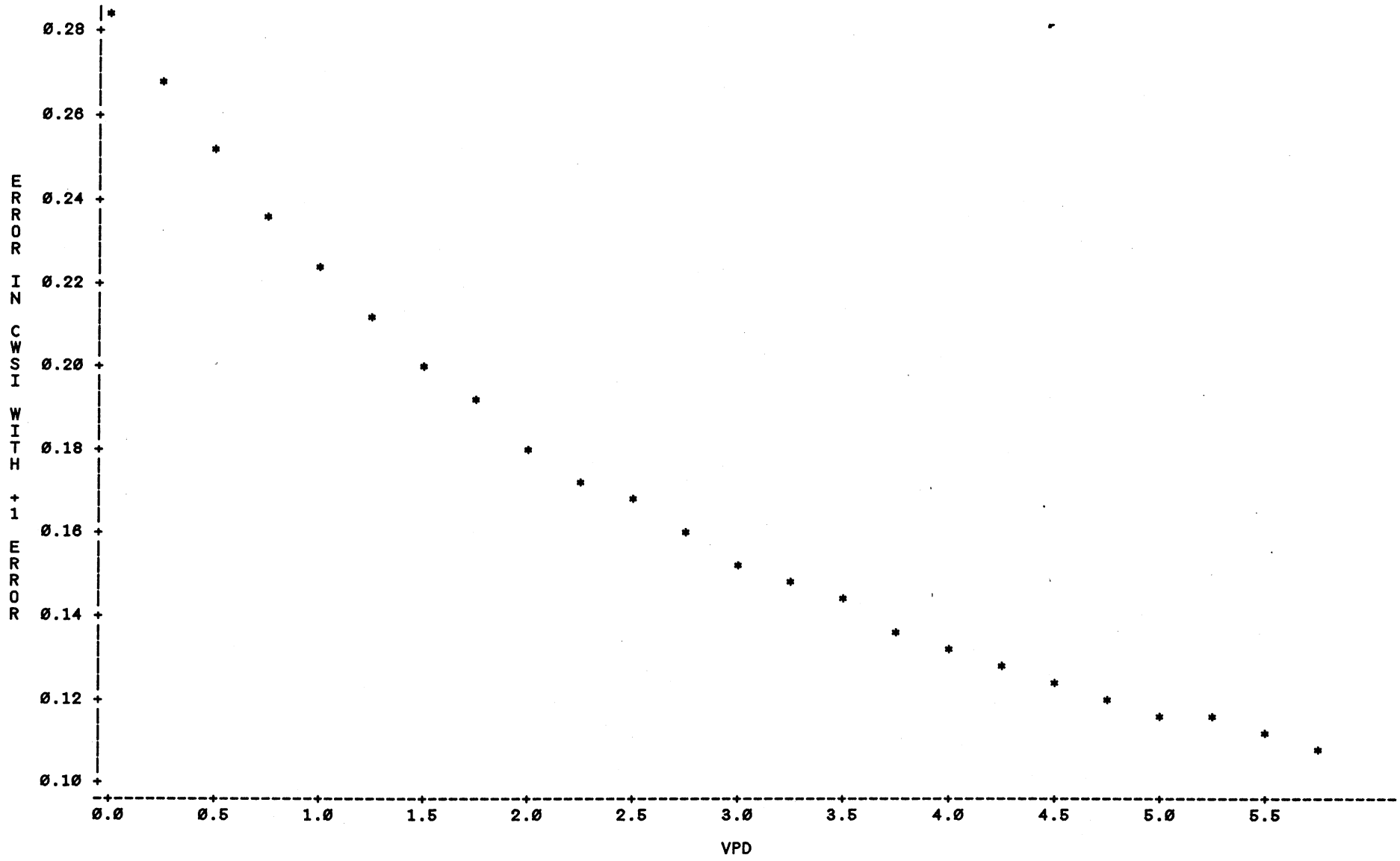
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *



NOTE: 3184 OBS HIDDEN

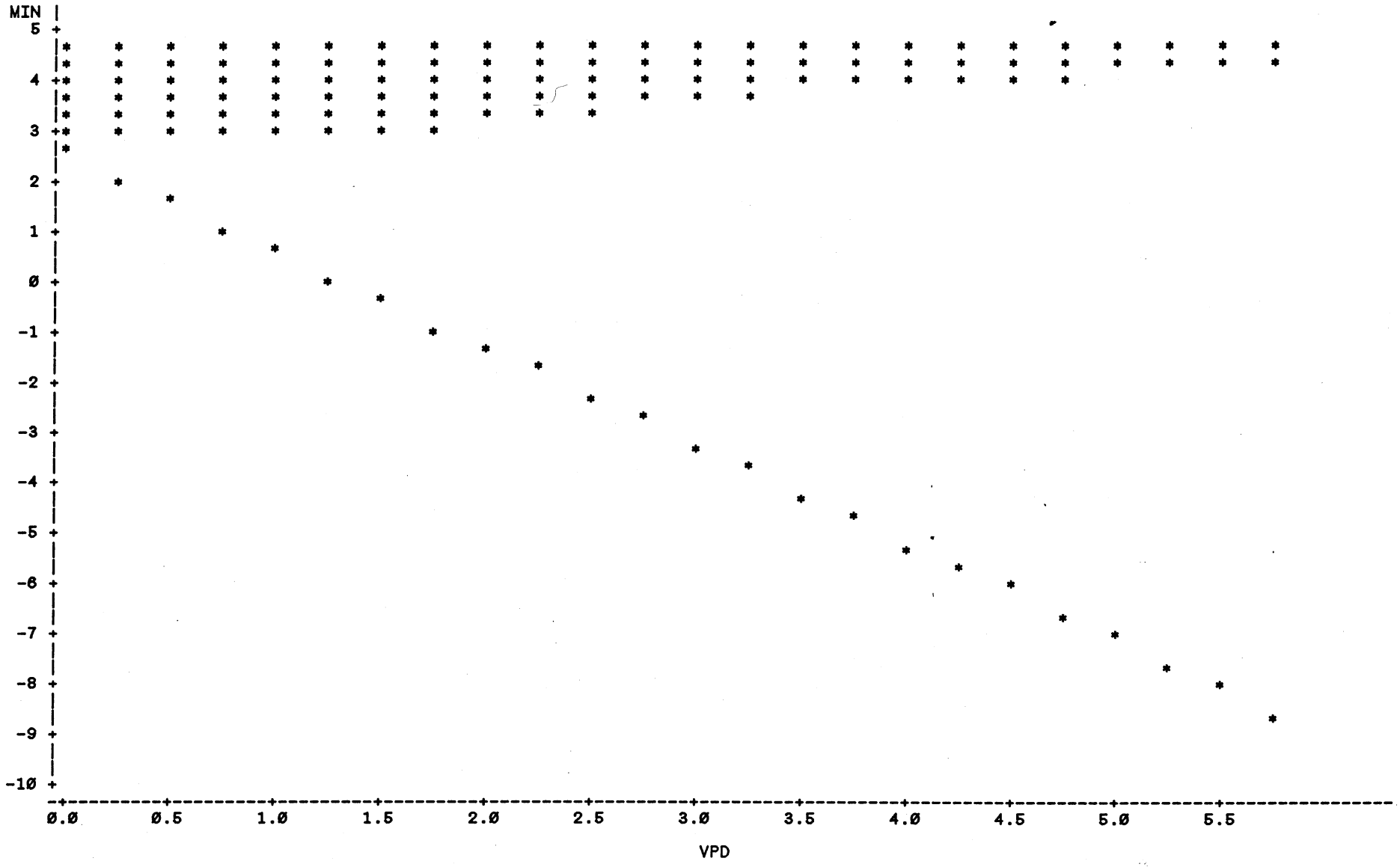
ERROR IN CWSI--LETTUCE
WITH 1 C ERROR IN (TC-TA)

PLOT OF ERROR2*VPD SYMBOL USED IS *



NOTE: 1592 OBS HIDDEN

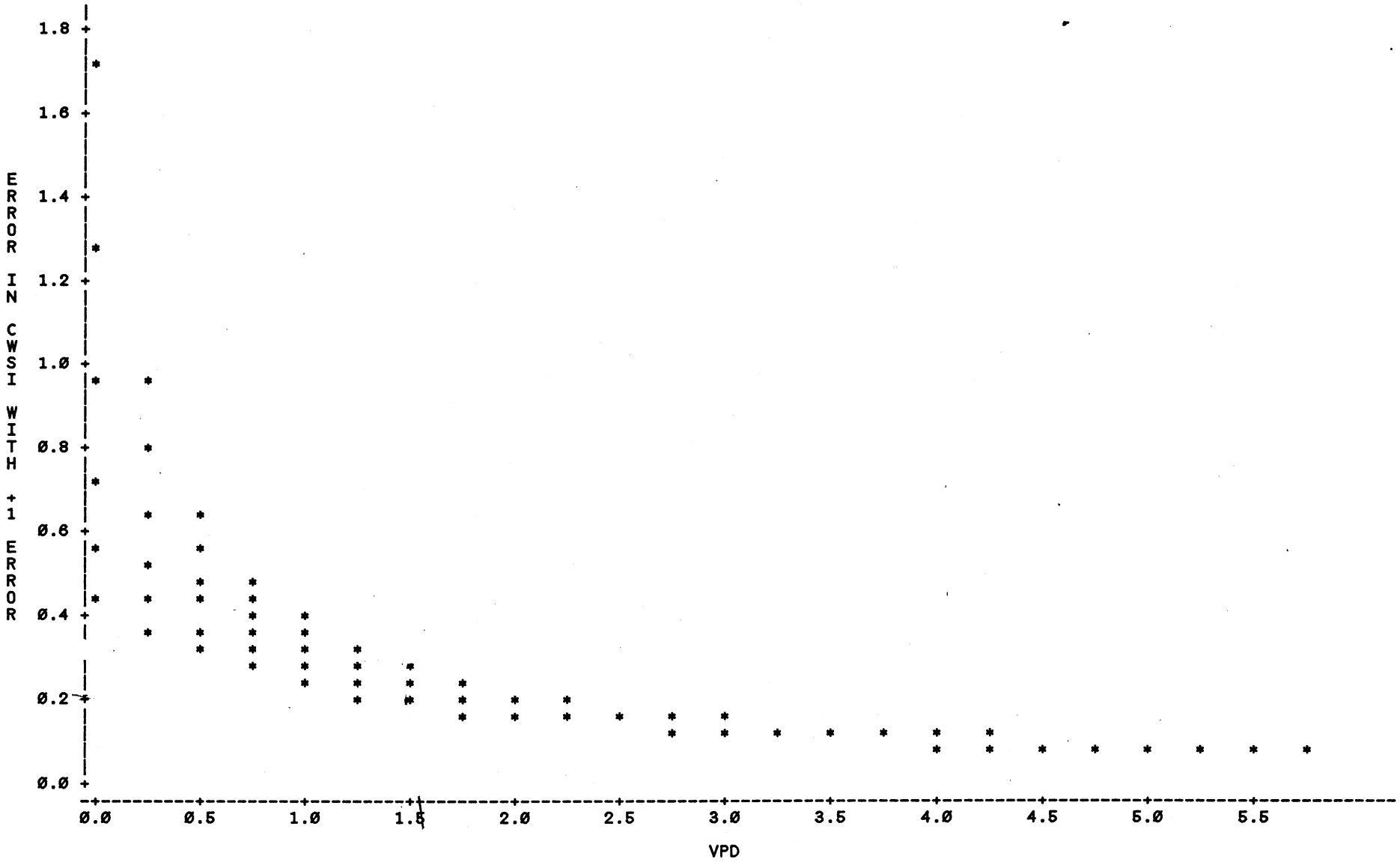
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *



NOTE: 3107 OBS HIDDEN

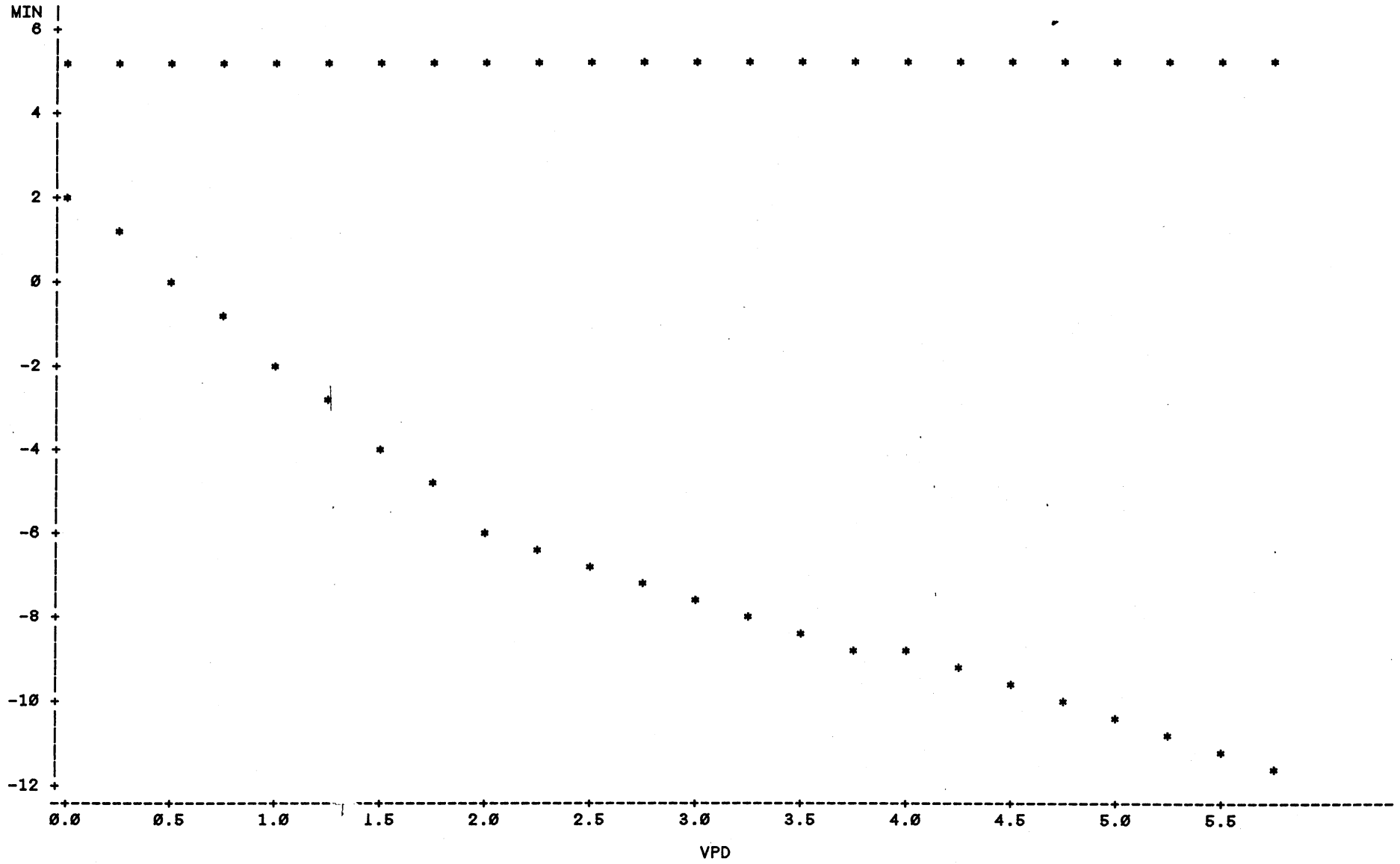
ERROR IN CWSI--SUGAR BEETS
WITH 1 C ERROR IN (TC-TA)

PLOT OF ERROR2*VPD SYMBOL USED IS *



NOTE: 1555 OBS HIDDEN

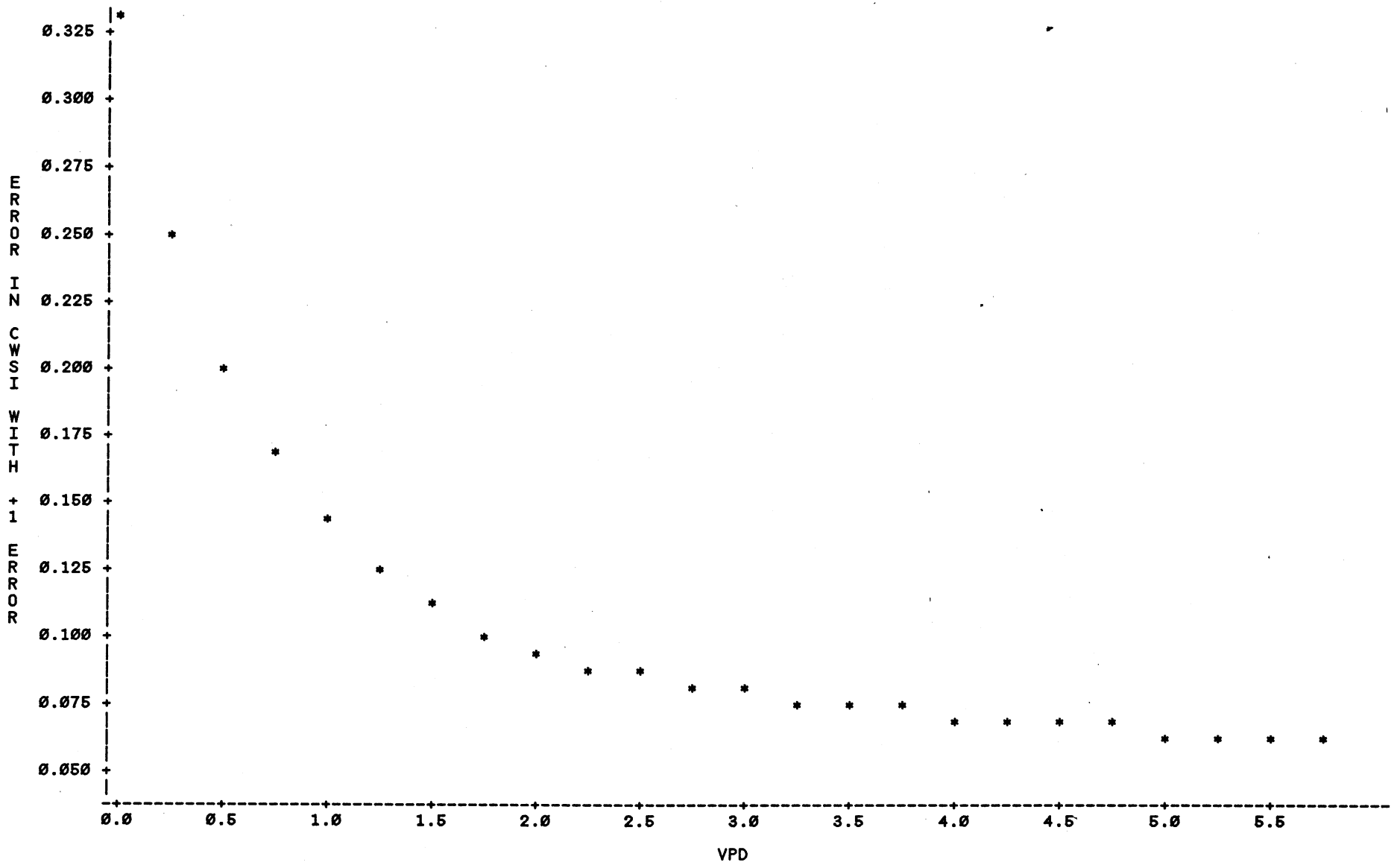
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *



NOTE: 3184 OBS HIDDEN

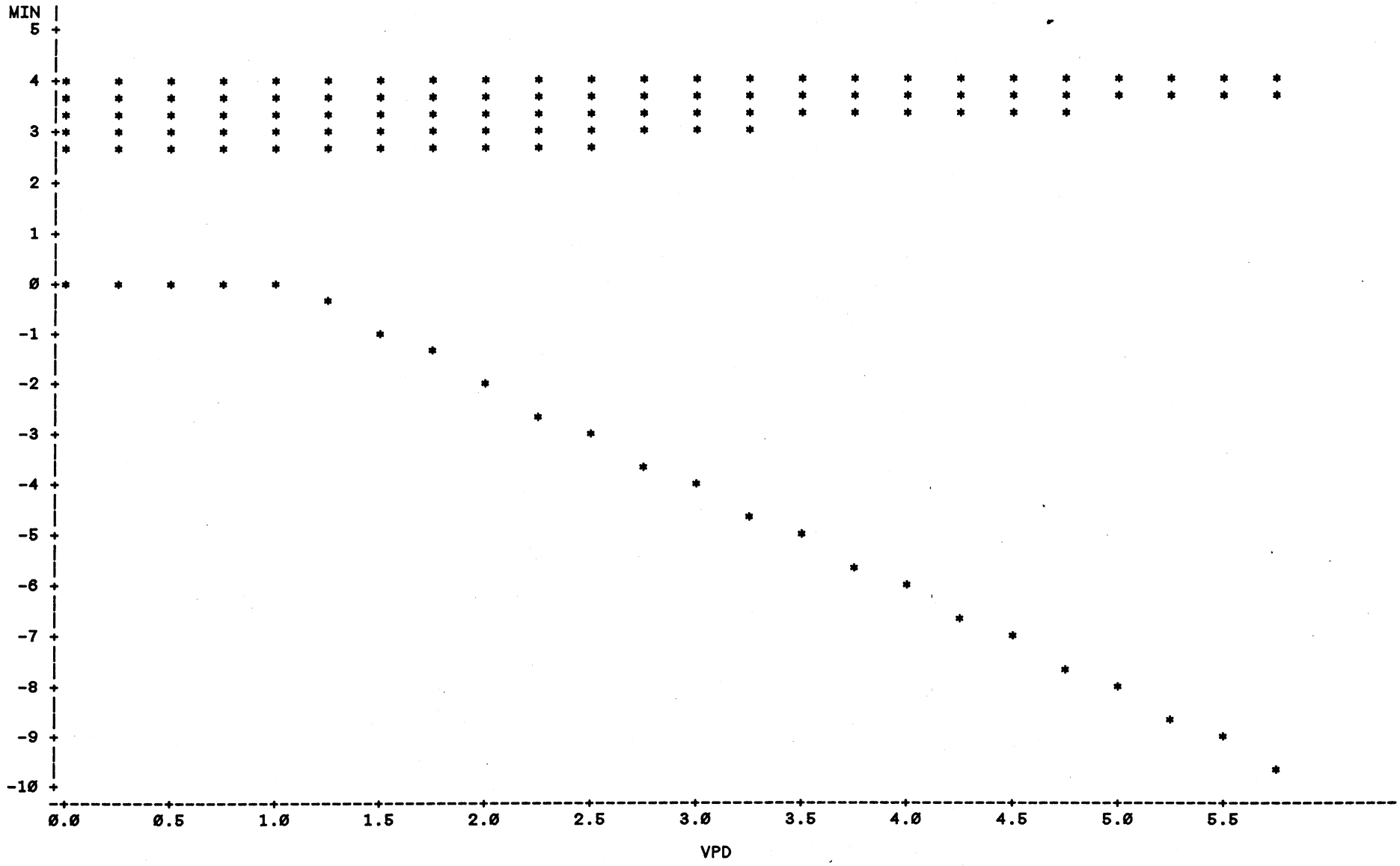
ERROR IN CWSI--WHEAT
WITH 1 C ERROR IN (TC-TA)

PLOT OF ERROR2*VPD SYMBOL USED IS *



NOTE: 1592 OBS HIDDEN

PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *

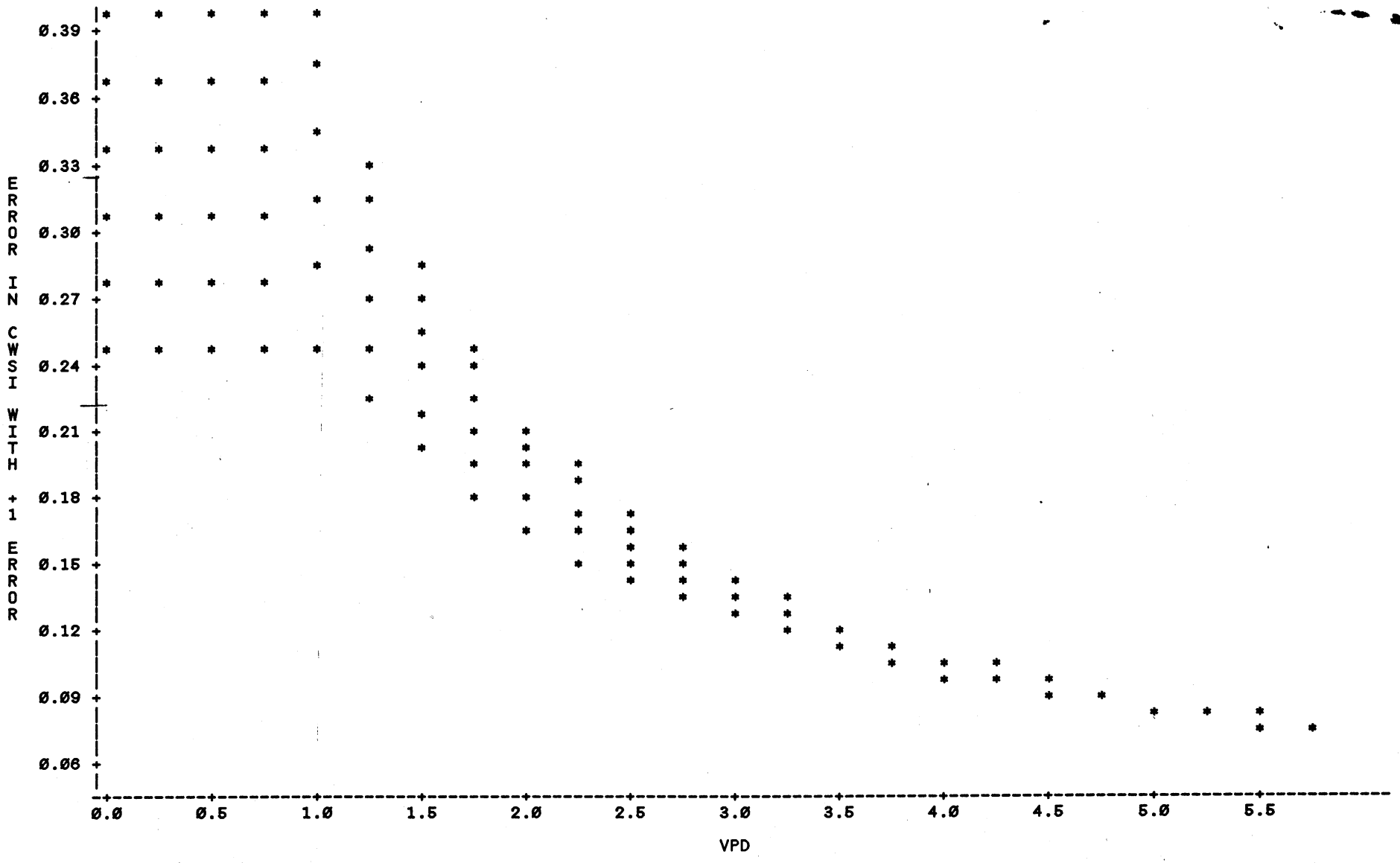


NOTE: 3115 OBS HIDDEN

ERROR IN CWSI--ALFALFA
WITH 1 C ERROR IN (TC-TA)

22:34 MONDAY, NOVEMBER 17, 1986 20

PLOT OF ERROR2*VPD SYMBOL USED IS *

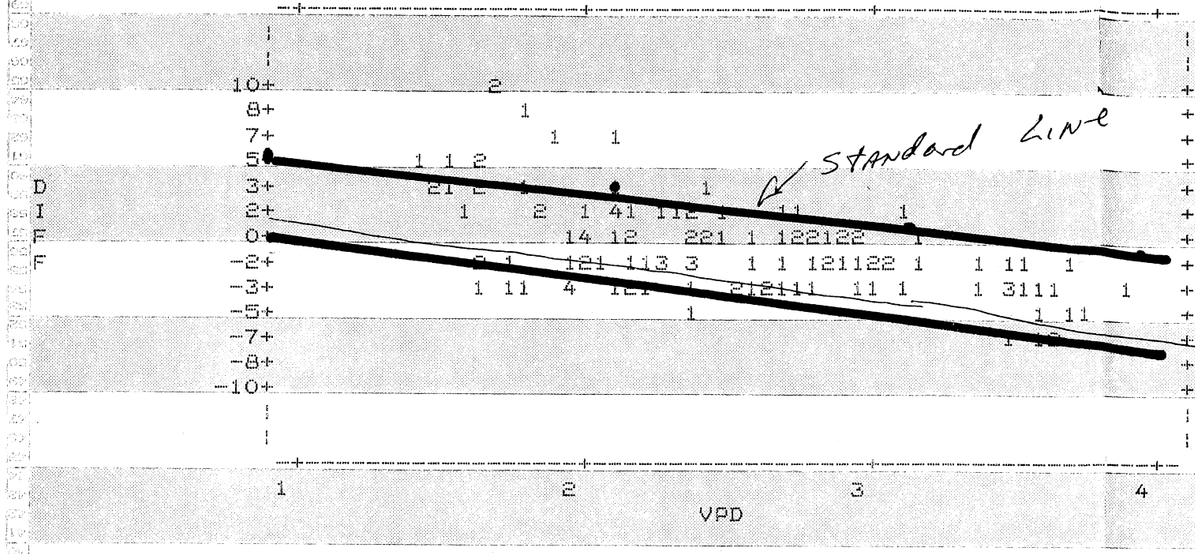


NOTE: 1527 OBS HIDDEN

Date/Time 02-25-1987 10:33:57
Data Base Name A:data
Description Imported from A:turf.dat

Scatter Plots

WINTER TURF DATA
X (VPD) by Y (DIFF) = Frequencies



7 - 1.9 * VPD upper = 13

2.0 - 1.9 * VPD upper = 8

OR

3.0 - 1.9 * VPD upper = 9

In order to comprehensively understand the behavior of the ST-27 index on turf grass, the following questions need to be answered There are six major categories of questions:

- Grass type/mixtures
- Management Practices/Design Considerations
- Soil Water
- Theoretical
- Interpretation
- Agronomic

Grass Type/Mixtures

- how does grass type (cool season, warm season),species (bermudas, fescue, etc) and variety affect the index?
grass specie-- (bermuda, fesuce, St. Augustine, etc., etc.)
grass variety-- (Penncross bermuda, Emerald bermuda , Toronto bermuda, etc, etc, etc, for each grass specie).

- What is the effect of grass mixtures on the turf index?

- How does naturally occuring dormancy affect the index? What is the effect of a mixture of dormant and rapdily growing species on the index?

Management Practices/Design Considerations

- grass useage--is the grass subjected to frequent traffic, such as a practice putting green, or is it seldom walked on (parks) by comparison?

- cutting height--given that all other factors remain the same, how does cutting height affect the index?

- does the type/sharpeness of lawn mower used to cut the turf have an effect?

- how much do grass clipplings (of what density?) affect the index?

- What effect does thatch have? how does this effect interact with Plant type, plant thickness, and surface wetness?

- What is the effect of variations in plant density? How does this effect interact with surfact soil wetness or dryness? How does this effect interact with windspeed?

- how does slope and aspect affect the index? Are differences in the index on sloped areas versus flat areas the result of seeing more thatch/soil or is there also a "real" effect, i.e., do sloped areas actual experience more(or less) stress, depending on their exposure to the sun? How does this affect index readings/mangement concerns on a green?

Benson,

I have received, we should visit briefly about this subject.

Steve

• cultivation practices--how does coring, top-dressing, vertical mowing, matting, adding wetting agents, etc. affect the index?

•What is the optimum irrigation timing sequence for a given type of turf, as a function of soil type, location, and useage? Can these timing sequences be inferred from index readings? How can "optimum" be defined?

•What management solutions are available for localized "hot spots" identified by the ST-27? Irrigating a hot spot via adjusted sprinkler patterns may result in waterlogging adjacent areas, which in turn would make the adjacent areas warmer. How detrimental is this? Must a green be rebuilt in order to effectively eliminate some hot-spots?

• what effect does mowing frequency have on the index?

• how does syringing interact with the index? Can the index be used after a syringing for any useful purpose?

• can sprinkler head distribution patterns be effectively judged with the index? How?

Soil Water

• how do index readings compare with tensiometer/soil moisture readings?

• how does salinity in the soil and water affect the index ?

• What is the effect of soil PH on the index?

• What is the relationship between morning dew patterns and afternoon turf temperature patterns? Morning dew patterns represent a competiting technology to find the dry spots on a green.

This is not A technology it is A phenotipical method. Subjective method. ("Best guess")

• What is the effect of soil oxygen depletion on the index? How long does this effect last? How long does it take for this effect to produce changes in visual quality (low index numbers, with poor visual characteristics).

• irrigation practices--how does the style of irrigation interact with index values ? How dependent is this on site specific soil characteristics and climatic conditions?

Theoretical

• What effect does windspeed have on the index? Under what conditions?

• What is the effect of air temperature on all the above interactions?

• how do index readings compare with soil temperature readings?

Interpretation

1. is a turf with poor visual qualities, but low index readings currently in the "recovery" mode?

2. how long does it take a particular grass species to recover good visual appearance after its visual characteristics have been impaired? How does this interact with the index?

3. what is the best standard with which to compare visual quality and agronomic health between turf located at different sites?

4. how does over-irrigation impact the index and turf quality, especially over time? Does this predispose an area to having problems if water supplies suddenly become restricted?

5. visual quality--what is the relationship between visual quality , the turf index and all the above variables.

Agronomic Concerns

1. disease effects on turf temperature -- is the disease fast acting (overnight) or does it develop over time, with a corresponding effect on plant temperatures? Does the disease affect plant temperatures?

2. fertilizer effects--what is the effect on plant temperatures of turf that is short in N,P,K or various micronutrients?

3. chemical effects--what happens to plant temperatures when various funsicides and insecticides are applied?

4. How does the index work on grasses which grow primarily in the shade?

5. What is the optimum rooting depth for a turf species? Can rooting depth be controlled with the index? How does time of year interact with this objective?

6. How does the optimum biological temperature of a grass species interact with the index and all the above? What is the optimum biological temperature for a given grass species, or grass mixture?

7. what is the effect of auotrphic and heterotrophic bacteria?

7 & I don't understand.

STANDARD OIL
ENGINEERED MATERIALS

Memorandum

To: S. C. DeSutter

Date: 11/9/87

From: B. R. Gardner

B. R. G.

Copy to:

RECEIVED
NOV 1 1 1987
S. C. DeSUTTER

Subject: Improved Technique for Measuring Non-Stressed Baseline Values

I believe we should incorporate an alternate index into our options. There are users who complain about inconsistency in the current index. Inconsistencies are the result of errors in estimating the true minimum temperature of a crop for a given day. The factors which may cause these errors include:

No. This isn't the only complaint. Mainly it is the inconsistency in a given day or field. This is what I have interpreted.

How does this affect plant temp?

We always denied it is was a problem.

Factor
Sunlight variability
Percent ground cover
Windspeed variations
CO_2 variations
(This factor, just recent discovered) CO_2 varies with soil moisture and the amount of decomposing organic matter.
Age of Crop
Sampling technique
Time of day
Genotype
Surface wetness of the soil
Instrument differences
Air temperature fluctuations
Baseline errors

It is probable that no mathematical model will be developed in the near-term which can remove all these sources of variability. It is also clear that Scheduler sales/reputation hinge on the ability to absolutely minimize all sources of variability not associated with transpiration. In other words, the Scheduler index must be consistent despite all aforementioned potential sources of error.

There is a way to accomplish this objective. I have tested this method on the cucumber data from Wisconsin and am convinced that this procedure should become a part of our options in selling/using the Scheduler.

The method requires a user to identify an area which has been recently irrigated (a piece of information which requires very little judgment). The user would simply walk into this area and take 30-40 samples. No index would be produced at this point. The user has just calibrated his baseline to adjust it to all the aforementioned sources of variability, including instrumentation.

Except in data just received, just irrigated could be under stress.

How is this done since the stress status of the field is not known (but by definition it should not be in a severely stressed status)? After the samples are taken, the CPU calculates the mean and standard deviation of the crop temperature and the mean sunlight level. The quantity [(Tc-Ta) - Std] for a reasonably non-stressed field is the minimum baseline.

How would this change the way in which the current index is calculated?

The current index is:

$$10 * (Diff - Min) / (Max - Min)$$

where Min = a + b * VPD

The new index is:

$$10 * (Diff - NMin) / (Max - Min)$$

where NMin is the statistical minimum

As you can see, the denominators are identical, since the denominator represents the potential spread between stressed and non-stressed plants. All that has been done is to substitute a statistically measured value for Min in place of a computed value based on VPD. The suggested substitution can be expected to greatly improve the stability of the index.

BRG/lb

does a 2 = a 2 from day to day?
what if my standard "good location" is already a 2 then how does this effect my interpretation?

STANDARD OIL
ENGINEERED MATERIALS

Memorandum

To: J. K. Riley

Date: 11/24/87

From: B. R. Gardner

Copy to:

Subject: DATA REQUIREMENTS FOR BASELINE DETERMINATIONS

1. Description of aiming technique. The technique must insure that the vast majority of vegetation in the field of view is sunlit. Shadows measured must be minimal. We should be responsible for defining the aiming technique.

2. Dates of rainfall and irrigation. Without these, interpretation of trends is difficult.

3. Yield and/or quality data. This allows us to determine if the patterns presented are representative of normal and below normal agronomic results.

4. A comparison area, i.e., an area which has a much lower yield than normal (less than 1/2 of normal). Irrigations, rainfall dates, yield/quality and Scheduler^{R} Plant Stress Monitor data from this area are also needed. The area does not need to be large.

5. Transfer of the data in the ACSII format to Standard Oil Engineered Materials Company on 5 1/4 inch diskettes. All data should be clearly documented.

6. An agronomic description of the life cycle of the crop:

   a. When the season begins.

   b. How the crop changes in physical appearance through the season.

   c. When harvest occurs.

   d. If a perennial crop, the importance of post-harvest treatments to the following year's crop.

   e. Factors which are known to affect the yield and quality of the crop. For example, sensitivities to particular nutrients or cultural practices.

   f. Critical time periods in crop/yield development.

7. A description of the cultural practices used. Are these practices representative of the industry? Are these industry standards or accepted practices?

8. Scheduler data should be obtained three times weekly (Monday, Wednesday, Friday) at a minimum.

9. Care must be taken to take data during optimal conditions as much as possible.

BRG/lb

THESE ARE THE RESEARCH BASELINES AS OF 6/28/1989

```
    ASPAR.    ,   0,     2.390,   -1.390,  6.0,     1.5,     -3.0,  7.0,     8.3,
    BEETS     ,   0,     5.160,   -2.300,  5.0,     1.5,     -3.0,  7.0,     8.3,
    BELL PEP  ,   0,     3.670,   -1.060,  7.0,     1.5,     -3.0,  7.0,     8.3,
    BLUBERRY  ,   0,     3.000,   -2.000,  8.0,     1.5,     -3.0,  7.0,     8.3
    BROCCOLI  ,   0,     0.000,   -2.000,  6.0,     1.5,     -3.0,  7.0,     8.3,
    CABBAGE   ,   0,     3.000,   -2.000,  6.0,     1.5,     -3.0,  7.0,     8.3,
    CAULIFL.  ,   0,     1.000,   -2.000,  6.0,     1.5,     -3.0,  7.0,     8.3,
    CELERY    ,   0,     0.500,   -2.500,  5.0,     1.5,     -3.0,  7.0,     8.3,
    CHARD     ,   0,     2.460,   -1.880,  5.0,     1.5,     -3.0,  7.0,     8.3,
    CHILE     ,   0,     2.208,   -1.948,  4.0,     1.5,     -3.0,  7.0,     8.3
    COWPEAS   ,   0,     1.320,   -1.840,  5.0,     1.5,     -3.0,  7.0,     8.3,
    FIG TREE  ,   0,     4.220,   -1.770,  5.0,     1.5,     -3.0,  7.0,     8.3,
    GRN BEAN  ,   0,     2.910,   -2.350,  5.0,     1.5,     -3.0,  7.0,     8.3,
    GUAYULE   ,   0,     1.870,   -1.750,  5.0,     1.5,     -3.0,  7.0,     8.3,
    KOHLRABI  ,   0,     2.010,   -2.170,  5.0,     1.5,     -3.0,  7.0,     8.3,
    HEAD LTC  ,   0,     0.500,   -1.500,  5.0,     1.5,     -3.0,  7.0,     8.3,
    LEAF LTC  ,   0,     4.180,   -2.960,  6.0,     1.5,     -3.0,  7.0,     8.3,
    LIMABEAN  ,   0,     2.140,   -1.390,  5.0,     1.5,     -3.0,  7.0,     8.3,
    MILLET    ,   0,     3.819,   -1.523,  5.0,     1.5,     -3.0,  7.0,     8.3,
    ORANGES   ,   0,     4.740,   -1.270,  8.0,     1.5,     -3.0,  7.0,     8.3,
    PEACHES   ,   0,     3.500,   -1.296,  6.0,     1.5,     -3.0,  7.0,     8.3,
    PEAS      ,   0,     2.740,   -2.130,  5.0,     1.5,     -3.0,  7.0,     8.3,
    PEPRMINT  ,   0,     1.000,   -1.620,  5.0,     1.5,     -3.0,  7.0,     8.3
    PUMPKIN   ,   0,     0.950,   -1.930,  5.0,     1.5,     -3.0,  7.0,     8.3,
    RASBERRY  ,   0,     3.000,   -2.000,  8.0,     1.5,     -3.0,  7.0,     8.3
    RICE      ,   0,     1.280,   -2.260,  5.0,     1.5,     -3.0,  7.0,     8.3,
    RUTABAGA  ,   0,     3.750,   -2.660,  5.0,     1.5,     -3.0,  7.0,     8.3,
    SEEDALF   ,   1,     0.700,   -1.880,  4.0,     1.5,     -3.0,  7.0,     8.3,
'   VEGETATIVE GROWTH FOR SEED ALFALFA= STAGE 1
    SEEDALF   ,   2,     0.250,   -1.410,  4.0,     1.5,     -3.0,  7.0,     8.3,
'   PRODUCTION OF FLOWER AND PODS FOR SEED ALFALFA=STAGE 2
    SEEDALF   ,   3,     0.400,   -1.240,  4.0,     1.5,     -3.0,  7.0,     8.3,
'   POD DRYING FOR SEED ALFALFA= STAGE 3
    SPEARMNT  ,   0,     2.000,   -1.720,  5.0,     1.5,     -3.0,  7.0,     8.3,
    SQUASH H  ,   0,     6.910,   -3.090,  5.0,     1.5,     -3.0,  7.0,     8.3,
    SQUASH Z  ,   0,     2.000,   -1.880,  5.0,     1.5,     -3.0,  7.0,     8.3,
    SUNFLOWR  ,   0,     0.660,   -1.950,  5.0,     1.5,     -3.0,  7.0,     8.3,
    TURF      ,   0,     7.000,   -1.900,  13.0,    1.5,     -2.0,  8.0,     8.3,
    TURNIP    ,   0,     1.940,   -2.260,  5.0,     1.5,     -3.0,  7.0,     8.3,
```

Commercial Baseline
6/28/89

ALFALFA	,	0,	2.040,	-2.020,	4.0,	1.5,	-3.0,	7.0,	8.3,
ALMONDS	,	0,	0.830,	-1.680,	5.0,	1.5,	-3.0,	7.0,	8.3,
APPLES	,	0,	2.446,	-1.296,	5.0,	1.5,	-3.0,	7.0,	8.3,
ASPAR.	,	0,	2.390,	-1.390,	6.0,	1.5,	-3.0,	7.0,	8.3,
BARLEY	,	1,	2.010,	-2.250,	5.0,	1.5,	-3.0,	7.0,	8.3,
BARLEY	,	2,	1.720,	-1.230,	5.0,	1.5,	-3.0,	7.0,	8.3,
CANTAL.	,	0,	0.000,	-1.270,	5.0,	1.5,	-3.0,	7.0,	8.3,
CARROTS	,	0,	4.120,	-2.260,	8.0,	1.5,	-3.0,	7.0,	8.3,
CORN	,	0,	2.670,	-2.059,	4.0,	1.5,	-3.0,	7.0,	8.3,
COTTON	,	0,	1.760,	-1.930,	3.0,	1.5,	-3.0,	7.0,	8.3,
CUCUMBER	,	0,	3.880,	-2.520,	5.0,	1.5,	-3.0,	7.0,	8.3,
GRAPES	,	0,	0.000,	-1.000,	8.0,	1.5,	-3.0,	7.0,	8.3,
JOJOBA	,	0,	2.000,	-0.800,	4.0,	4.0,	-3.0,	7.0,	8.3,
PECANS	,	0,	0.030,	-0.590,	6.0,	1.5,	-3.0,	7.0,	8.3,
POTATOES	,	0,	2.170,	-1.960,	6.0,	1.5,	-3.0,	7.0,	8.3,
SORGHUM	,	0,	2.530,	-1.960,	5.0,	1.5,	-3.0,	7.0,	8.3,
SOYBEANS	,	0,	2.510,	-2.020,	4.0,	1.5,	-3.0,	7.0,	8.3,
STRAWB.	,	0,	3.600,	-0.960,	8.0,	1.5,	-3.0,	7.0,	8.3,
SGR BEET	,	0,	2.500,	-1.920,	5.0,	1.5,	-3.0,	7.0,	8.3,
TOMATOES	,	0,	3.170,	-1.820,	5.0,	1.5,	-3.0,	7.0,	8.3,
WATERMEL.	,	0,	-0.740,	-1.230,	6.0,	1.5,	-3.0,	7.0,	8.3,
WHEAT	,	1,	0.990,	-2.080,	5.0,	1.5,	-3.0,	7.0,	8.3,
WHEAT	,	2,	0.330,	-1.190,	5.0,	1.5,	-3.0,	7.0,	8.3,
LOW	,	0,	3.380,	-3.250,	12.0,	1.5,	-3.0,	7.0,	8.3,
HIGH	,	0,	3.500,	-1.680,	6.0,	1.5,	-3.0,	7.0,	8.3,

estion, the new values become the default parameters for the
urrent session only and are not saved to diskette.

*Note!! You have the option of changing the tabular baseline data
which has been excerpted in part from Idso (1982). To do this type
"0" in answer to the question asking Crop ID Number. This will
display the Crop Baseline data and give you the option to choose a

new crop. Pick a number and change the data by answering the
questions. At the finish of this option you will have the option of
renaming the crop common name and either replacing the current crop
id with the updated parameters or adding the information to the
table. The first 2 letters of the crop common name and the 2 numeric
crop id codes will be combined with the day of the year to create the
file name and minimize redundancy.

*It is anticipated that this convention of updating parameters and
assigning default values to a particular diskette can be used to
simplify operation. Different crop ids can be assigned to the same
common names and baseline data if there is a need to keep the data
for different experiments separate or if different numbers of plots
are involved.

*** End **********

id	---Common Name---	--Scientific Name--	slope	inter	Ra	Rcp
1	Alfalfa	M. sativa L.	-1.92	0.51	10.0	5.0
2	Barley, pre-heading	H. vulgare L.	-2.25	2.01	10.0	5.0
3	Barley, post-heading	H. vulgare L.	-1.23	1.72	10.0	5.0
4	Bean	P. vulgaris L.	-2.35	2.91	10.0	5.0
5	Corn, no-tassels	Z. mays L.	-1.97	3.11	10.0	5.0
6	Cotton	G. hirsutum L.	-2.09	1.49	10.0	5.0
7	Guayule	P. argentatum G.	-1.75	1.87	10.0	5.0
8	Soybean	G. max L. Merr.	-1.34	1.44	10.0	5.0
9	Sugar Beet	B. vulgaris L.	-1.92	2.50	10.0	5.0
10	Sunflower	H. annuus L.	-1.95	0.66	10.0	5.0
11	Tomato	L. esculentum Mill.	-1.96	2.86	10.0	5.0
12	Wheat, pre-heading	T. durum Desf.	-3.25	3.38	10.0	5.0
13	Wheat, post-heading	T. durum Desf.	-2.11	2.88	10.0	5.0
14	crop x	I. dontus knowus	1.00	0.00	10.0	5.0
15	crop y	I. dontus knowus	1.00	0.00	10.0	5.0
16	crop z	I. dontus knowus	1.00	0.00	10.0	5.0

enter 0 to list current crop id numbers
enter crop id number (0):

days selected. The predicted irrigation day is calculated via linear
regression of CWSI on days for a particular plot. The 95% error
associated with the predicted day usually appears relatively large. This
error will always be at a minimum when the "predicted" day is near the

```
  type cwsibak.part
** CWSI Parameter File

**** Crop Parameters ****
crop id number                1      see table below
number of plots:              4      of data collected
Psychrometric Constant:       0.066 in kPa/C

**** Ambient Meteorological Conditions ****
Barometric Press:           100.0    in kPa
Net Radiation:              600.0    in W/M^2
Air Density:                  1.29   in Kg/M^3
Air Heat Capacity:         1003.2    in J/(Kg C)

**** Program Parameters ****
use drive A for output data
```

**** Slope & Intercepts (from Idso, 1982 table 1) ****

id #	---Common Name---	--Scientific Name--	slope	inter	Ra	Rcp	Threshol CWSI
1	Alfalfa	M. sativa L.	-1.92	0.51	10.0	5.0	0.25
2	Barley, pre-heading	H. vulgare L.	-2.25	2.01	10.0	5.0	0.25
3	Barley, post-heading	H. vulgare L.	-1.23	1.72	10.0	5.0	0.25
4	Bean	P. vulgaris L.	-2.35	2.91	10.0	5.0	0.25
5	Corn, no-tassels	Z. mays L.	-1.97	3.11	10.0	5.0	0.25
6	Cotton	G. hirsutum L.	-2.09	1.49	10.0	5.0	0.25
7	Guayule	P. argentatum G.	-1.75	1.87	10.0	5.0	0.25
8	Soybean	G. max L. Merr.	-1.34	1.44	10.0	5.0	0.25
9	Sugar Beet	B. vulgaris L.	-1.92	2.50	10.0	5.0	0.25
10	Sunflower	H. annuus L.	-1.95	0.66	10.0	5.0	0.25
11	Tomato	L. esculentum Mill.	-1.96	2.86	10.0	5.0	0.25
12	Wheat, pre-heading	T. durum Desf.	-3.25	3.38	10.0	5.0	0.25
)	Wheat, post-heading	T. durum Desf.	-2.11	2.88	10.0	5.0	0.25
14	crop x	I. dontus knowus	1.00	0.00	10.0	5.0	0.25
15	crop y	I. dontus knowus	1.00	0.00	10.0	5.0	0.25
16	crop z	I. dontus knowus	1.00	0.00	10.0	5.0	0.25

```
A>
```

Commercial Baselines
6/28/89

Crop	Stage	Intercept	Slope	upper limit	Dotted line for graph	lower graph limit	upper graph limit
ALFALFA	0,	2.040,	-2.020,	4.0,	1.5,	-3.0,	7.0,
ALMONDS	0,	0.830,	-1.680,	5.0,	1.5,	-3.0,	7.0,
APPLES	0,	2.446,	-1.296,	5.0,	1.5,	-3.0,	7.0,
ASPAR.	0,	2.390,	-1.390,	6.0,	1.5,	-3.0,	7.0,
BARLEY	1,	2.010,	-2.250,	5.0,	1.5,	-3.0,	7.0,
BARLEY	2,	1.720,	-1.230,	5.0,	1.5,	-3.0,	7.0,
CANTAL.	0,	0.000,	-1.270,	5.0,	1.5,	-3.0,	7.0,
CARROTS	0,	4.120,	-2.260,	8.0,	1.5,	-3.0,	7.0,
→ CORN	0,	2.670,	-2.059,	4.0,	1.5,	-3.0,	7.0,
COTTON	0,	1.760,	-1.930,	3.0,	1.5,	-3.0,	7.0,
CUCUMBER	0,	3.880,	-2.520,	5.0,	1.5,	-3.0,	7.0,
GRAPES	0,	0.000,	-1.000,	8.0,	1.5,	-3.0,	7.0,
JOJOBA	0,	2.000,	-0.800,	4.0,	4.0,	-3.0,	7.0,
PECANS	0,	0.030,	-0.590,	6.0,	1.5,	-3.0,	7.0,
POTATOES	0,	2.170,	-1.960,	6.0,	-1.0,	-5.0,	5.0,
SORGHUM	0,	2.530,	-1.960,	5.0,	1.5,	-3.0,	7.0,
SOYBEANS	0,	2.510,	-2.020,	4.0,	1.5,	-3.0,	7.0,
STRAWB.	0,	3.600,	-0.960,	8.0,	1.5,	-3.0,	7.0,
SGR BEET	0,	2.500,	-1.920,	5.0,	1.5,	-3.0,	7.0,
TOMATOES	0,	3.170,	-1.820,	5.0,	1.5,	-3.0,	7.0,
WATERMEL.	0,	-0.740,	-1.230,	6.0,	1.5,	-3.0,	7.0,
WHEAT	1,	0.990,	-2.080,	5.0,	1.5,	-3.0,	7.0,
WHEAT	2,	0.330,	-1.190,	5.0,	1.5,	-3.0,	7.0,
LOW	0,	3.380,	-3.250,	12.0,	1.5,	-3.0,	7.0,
HIGH	0,	3.500,	-1.680,	6.0,	1.5,	-3.0,	7.0,

difference should be 10.0 for a neat graph

THESE ARE THE RESEARCH BASELINES AS OF 6/28/1989

```
ASPAR.    ,  0,   2.390,  -1.390, 6.0,   1.5,   -3.0, 7.0,   8.3,
BEETS     ,  0,   5.160,  -2.300, 5.0,   1.5,   -3.0, 7.0,   8.3,
BELL PEP  ,  0,   3.670,  -1.060, 7.0,   1.5,   -3.0, 7.0,   8.3,
BLUBERRY  ,  0,   3.000,  -2.000, 8.0,   1.5,   -3.0, 7.0,   8.3
BROCCOLI  ,  0,   0.000,  -2.000, 6.0,   1.5,   -3.0, 7.0,   8.3,
CABBAGE   ,  0,   3.000,  -2.000, 6.0,   1.5,   -3.0, 7.0,   8.3,
CAULIFL.  ,  0,   1.000,  -2.000, 6.0,   1.5,   -3.0, 7.0,   8.3,
CELERY    ,  0,   0.500,  -2.500, 5.0,   1.5,   -3.0, 7.0,   8.3,
CHARD     ,  0,   2.460,  -1.880, 5.0,   1.5,   -3.0, 7.0,   8.3,
CHILE     ,  0,   2.208,  -1.948, 4.0,   1.5,   -3.0, 7.0,   8.3
COWPEAS   ,  0,   1.320,  -1.840, 5.0,   1.5,   -3.0, 7.0,   8.3,
FIG TREE  ,  0,   4.220,  -1.770, 5.0,   1.5,   -3.0, 7.0,   8.3,
GRN BEAN  ,  0,   2.910,  -2.350, 5.0,   1.5,   -3.0, 7.0,   8.3,
GUAYULE   ,  0,   1.870,  -1.750, 5.0,   1.5,   -3.0, 7.0,   8.3,
KOHLRABI  ,  0,   2.010,  -2.170, 5.0,   1.5,   -3.0, 7.0,   8.3,
HEAD LTC  ,  0,   0.500,  -1.500, 5.0,   1.5,   -3.0, 7.0,   8.3,
LEAF LTC  ,  0,   4.180,  -2.960, 6.0,   1.5,   -3.0, 7.0,   8.3,
LIMABEAN  ,  0,   2.140,  -1.390, 5.0,   1.5,   -3.0, 7.0,   8.3,
MILLET    ,  0,   3.819,  -1.523, 5.0,   1.5,   -3.0, 7.0,   8.3,
ORANGES   ,  0,   4.740,  -1.270, 8.0,   1.5,   -3.0, 7.0,   8.3,
PEACHES   ,  0,   3.500,  -1.296, 6.0,   1.5,   -3.0, 7.0,   8.3,
PEAS      ,  0,   2.740,  -2.130, 5.0,   1.5,   -3.0, 7.0,   8.3,
PEPRMINT  ,  0,   1.000,  -1.620, 5.0,   1.5,   -3.0, 7.0,   8.3
PUMPKIN   ,  0,   0.950,  -1.930, 5.0,   1.5,   -3.0, 7.0,   8.3,
RASBERRY  ,  0,   3.000,  -2.000, 8.0,   1.5,   -3.0, 7.0,   8.3
RICE      ,  0,   1.280,  -2.260, 5.0,   1.5,   -3.0, 7.0,   8.3,
RUTABAGA  ,  0,   3.750,  -2.660, 5.0,   1.5,   -3.0, 7.0,   8.3,
SEEDALF   ,  1,   0.700,  -1.880, 4.0,   1.5,   -3.0, 7.0,   8.3,
' VEGETATIVE GROWTH FOR SEED ALFALFA= STAGE 1
SEEDALF   ,  2,   0.250,  -1.410, 4.0,   1.5,   -3.0, 7.0,   8.3,
' PRODUCTION OF FLOWER AND PODS FOR SEED ALFALFA=STAGE 2
SEEDALF   ,  3,   0.400,  -1.240, 4.0,   1.5,   -3.0, 7.0,   8.3,
' POD DRYING FOR SEED ALFALFA= STAGE 3
SPEARMNT  ,  0,   2.000,  -1.720, 5.0,   1.5,   -3.0, 7.0,   8.3,
SQUASH H  ,  0,   6.910,  -3.090, 5.0,   1.5,   -3.0, 7.0,   8.3,
SQUASH Z  ,  0,   2.000,  -1.880, 5.0,   1.5,   -3.0, 7.0,   8.3,
SUNFLOWR  ,  0,   0.660,  -1.950, 5.0,   1.5,   -3.0, 7.0,   8.3,
TURF      ,  0,   7.000,  -1.900, 13.0,  1.5,   -2.0, 8.0,   8.3,
TURNIP    ,  0,   1.940,  -2.260, 5.0,   1.5,   -3.0, 7.0,   8.3,
```

Agricultural
Experiment Station
Malheur
Experiment Station

Oregon State University

595 Onion Avenue
Ontario, Oregon 97914

(503) 889-2174

November 21, 1989

Dr. James E. Simon
Department of Horticulture
Purdue University
West Lafayette, Indiana 47907

Dear Jim,

Reviewing our mint data, there are only a few observations for peppermint and spearmint that are useful for baseline maximum cooling curves. To be useful we need bright sunlight, mid-season growth, mid-day readings, and wet soil conditions. We have only 20 such data points for peppermint and 20 for spearmint.

Baseline curves are the following:

Peppermint

$\Delta T = 0.66 - 1.49$ VPD $\quad r^2 = 0.70$

Spearmint

$\Delta T = 0.86 - 1.46$ VPD $\quad r^2 = 0.81$

Both mints together

$\Delta T = 0.77 - 1.48$ VPD $\quad r^2 - 0.74$

The data and statistical analyses are included for your consideration. I would appreciate your comments and your baseline information.

Sincerely,

Clint

Clinton C. Shock
Superintendent

CS/mj
cc: Bronson Gardner ✓
Tim Stieber

Bronson,
Are these functions reasonable? What other data exists?
Clint

Mint Maximum Cooling Baselines, Ontario, Oregon.

	PEPPERΔT	VPD	SPEARΔT	VPD	MINTΔT	VPD
1	-1.0	1.90	-1.3	1.91	-1.0	1.90
2	-0.8	1.91	-1.3	1.82	-0.8	1.91
3	-0.8	1.87	-2.0	1.92	-0.8	1.87
4	0.5	1.86	-0.5	2.01	0.5	1.86
5	-2.0	2.49	-2.9	2.85	-2.0	2.49
6	-4.0	2.57	-3.4	2.72	-4.0	2.57
7	-3.8	2.65	-3.7	2.77	-3.8	2.65
8	-4.0	2.82	-3.4	2.55	-4.0	2.82
9	-3.9	2.19	-3.1	2.08	-3.9	2.19
10	-3.4	2.01	-0.5	1.84	-3.4	2.01
11	-4.5	2.05	-2.1	1.79	-4.5	2.05
12	-2.8	1.82	-2.3	1.85	-2.8	1.82
13	-3.6	2.73	-2.5	2.60	-3.6	2.73
14	-3.0	2.64	-3.6	2.76	-3.0	2.64
15	-4.1	2.65	-4.2	2.82	-4.1	2.65
16	-3.7	2.59	-4.4	2.71	-3.7	2.59
17	-5.8	4.88	-5.3	4.67	-5.8	4.88
18	-7.0	5.00	-5.5	4.61	-7.0	5.00
19	-6.5	5.00	-6.1	4.67	-6.5	5.00
20	-6.8	5.04	-6.1	4.84	-6.8	5.04
21					-1.3	1.91
22					-1.3	1.82
23					-2.0	1.92
24					-0.5	2.01
25					-2.9	2.85
26					-3.4	2.72
27					-3.7	2.77
28					-3.4	2.55
29					-3.1	2.08
30					-0.5	1.84
31					-2.1	1.79
32					-2.3	1.85
33					-2.5	2.60
34					-3.6	2.76
35					-4.2	2.82
36					-4.4	2.71
37					-5.3	4.67
38					-5.5	4.61
39					-6.1	4.67
40					-6.1	4.84

Equation: Y= .7733158+-1.47726* X; Correlation:-.8618003
Enter áì to continue, or ESC to quit --

----------Multiple Regression----------

Date/Time 11-21-1989 16:08:00
Data Base Name C:MintCWSI
Description Data base created at 15:12:19 on 11-21-1989

Multiple Regression Report

Dependent Variable: PEPPERΔT

Independent Variable	Parameter Estimate	Stndized Estimate	Standard Error	t-value (b=0)	Prob. Level	Seq. R-Sqr	Simple R-Sqr
Intercept	.6645349	0.0000	.6981179	0.95	0.3538		
VPD	-1.487395	-0.8371	.2290976	-6.49	0.0000	0.7008	0.7008

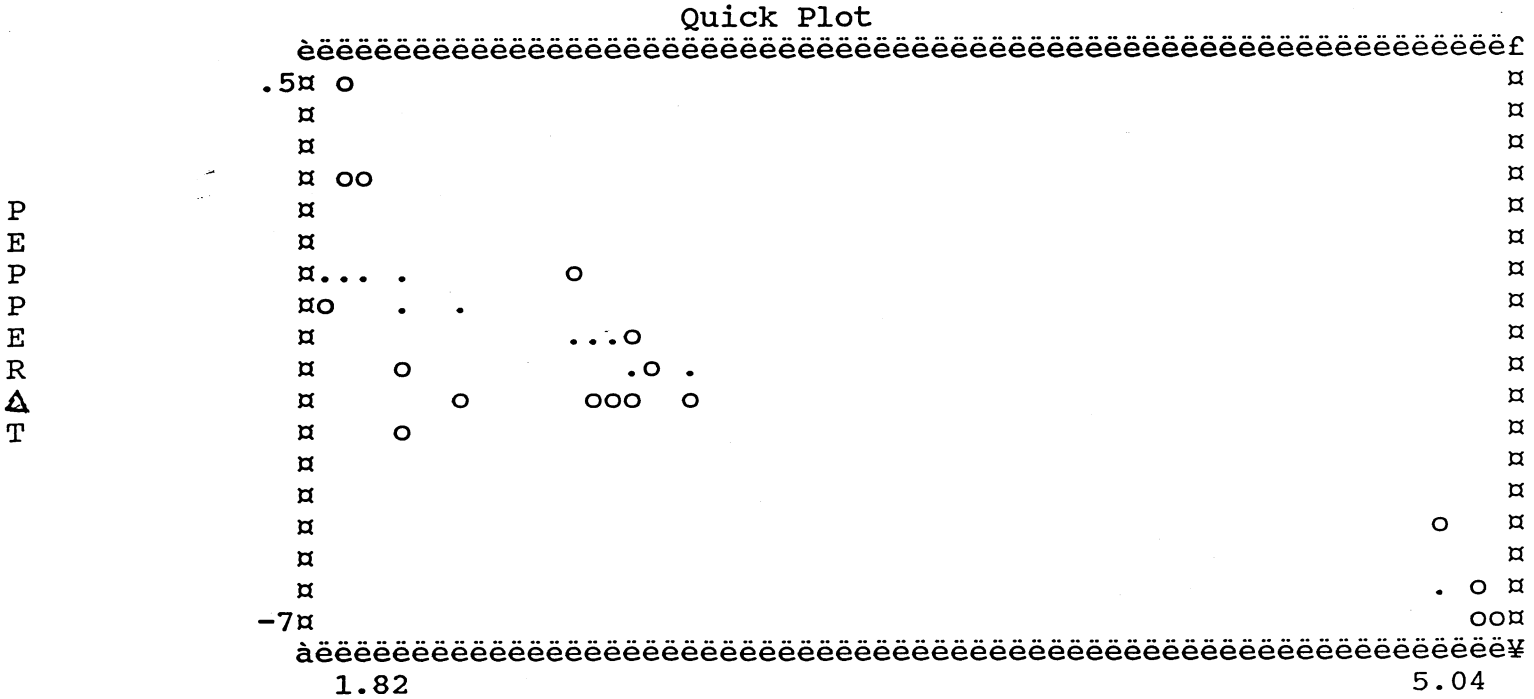
Analysis of Variance Report

Dependent Variable: PEPPERΔT

Source	df	Sums of Squares (Sequential)	Mean Square	F-Ratio	Prob. Level
Constant	1	252.05	252.05		
Model	1	55.61892	55.61892	42.15	0.000
Error	18	23.75108	1.319504		
Total	19	79.37	4.177369		

Root Mean Square Error	1.148697
Mean of Dependent Variable	-3.55
Coefficient of Variation	-.3235766
R Squared	0.7008
Adjusted R Squared	0.6841

Quick Plot



Equation: Y= .6645349+-1.487395* X; Correlation:-.8371111

Multiple Regression

Date/Time 11-21-1989 16:09:06
Data Base Name C:MintCWSI
Description Data base created at 15:12:19 on 11-21-1989

Multiple Regression Report

Dependent Variable: SPEARΔT

Independent Variable	Parameter Estimate	Stndized Estimate	Standard Error	t-value (b=0)	Prob. Level	Seq. R-Sqr	Simple R-Sqr
Intercept	.8610504	0.0000	.4929856	1.75	0.0977		
VPD	-1.459419	-0.9008	.1658599	-8.80	0.0000	0.8114	0.8114

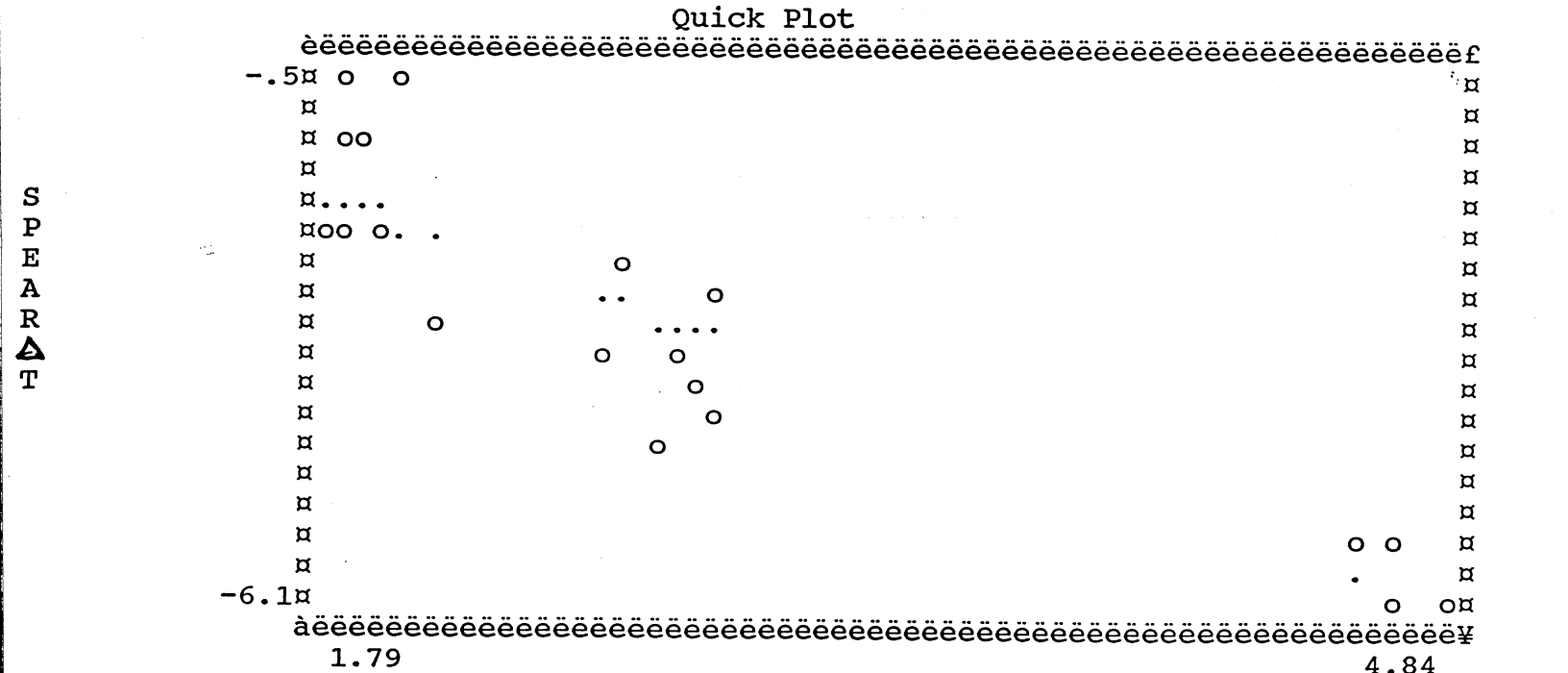
Analysis of Variance Report

Dependent Variable: SPEARΔT

Source	df	Sums of Squares (Sequential)	Mean Square	F-Ratio	Prob. Level
Constant	1	206.082	206.082		
Model	1	44.86708	44.86708	77.42	0.000
Error	18	10.43092	.5794958		
Total	19	55.298	2.910421		

Root Mean Square Error	.7612462
Mean of Dependent Variable	-3.21
Coefficient of Variation	-.2371483
R Squared	0.8114
Adjusted R Squared	0.8009

Quick Plot



Equation: Y= .8610504+-1.459419* X; Correlation:-.9007602

----------Multiple Regression----------

Date/Time 11-21-1989 16:09:52
Data Base Name C:MintCWSI
Description Data base created at 15:12:19 on 11-21-1989

Multiple Regression Report

Dependent Variable: C5 Mint ΔT

Independent Variable	Parameter Estimate	Stndized Estimate	Standard Error	t-value (b=0)	Prob. Level	Seq. R-Sqr	Simple R-Sqr
Intercept	.7733159	0.0000	.4245671	1.82	0.0764		
C6 VPD	-1.47726	-0.8618	.1410518	-10.47	0.0000	0.7427	0.7427

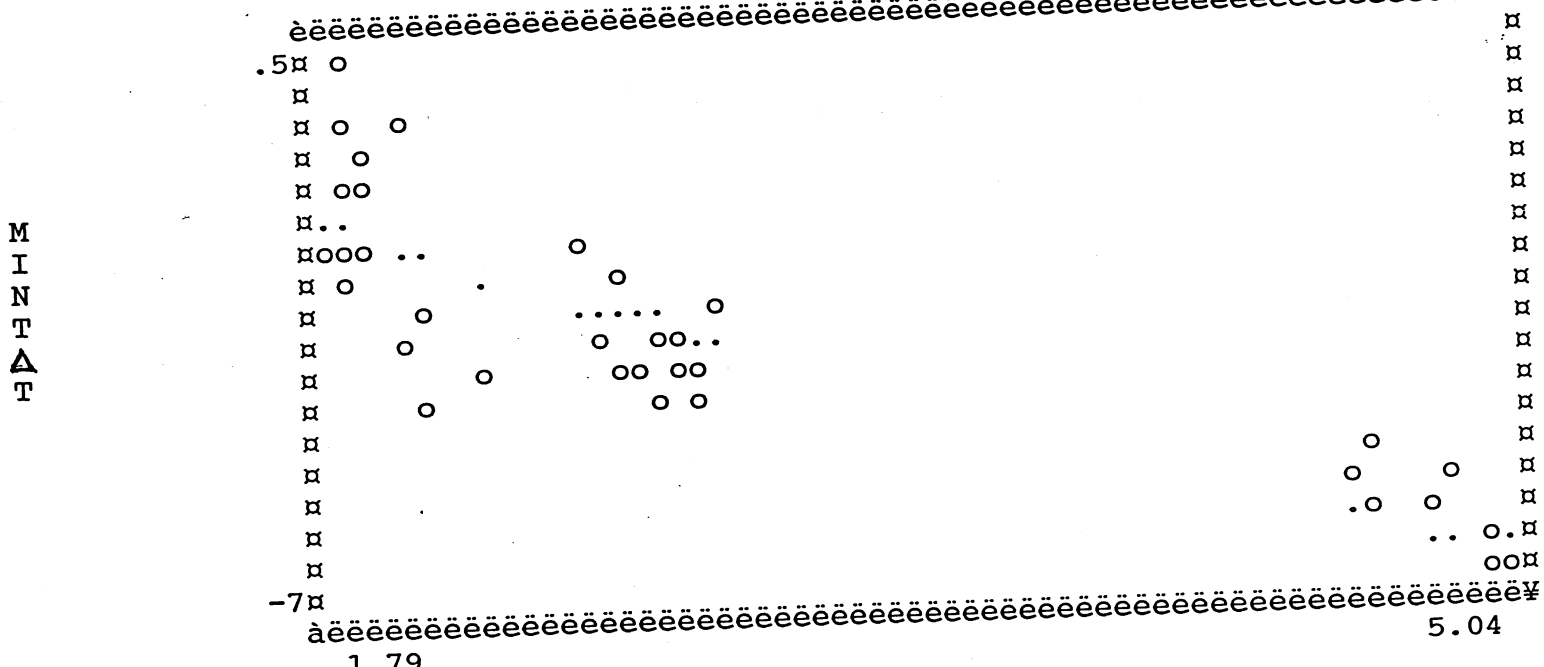
Analysis of Variance Report

Dependent Variable: C5 Mint ΔT

Source	df	Sums of Squares (Sequential)	Mean Square	F-Ratio	Prob. Level
Constant	1	456.976	456.976		
Model	1	100.8765	100.8765	109.69	0.000
Error	38	34.94754	.9196722		
Total	39	135.824	3.482667		

Root Mean Square Error	.9589954
Mean of Dependent Variable	-3.38
Coefficient of Variation	-.2837265
R Squared	0.7427
Adjusted R Squared	0.7359

Quick Plot



Equation: Y= .7733158+-1.47726* X; Correlation:-.8618003

Agricultural
Experiment Station
Malheur
Experiment Station

Oregon State University

595 Onion Avenue
Ontario, Oregon 97914

(503) 889-2174

Baselines for peppermint mint Spearmint

November 23, 1989

Dr. Bronson Gardner
The Carborundum Company
P.O. Box 391316
Solon, OH 44139

Dear Bronson,

We are sending you in a separate package via UPS the Scheduler. Please note it has been two years since you last went through the machine to check for defects and wear.

Sincerely,

Clint

Clinton C. Shock
Superintendent

CS/mj

Mint- Maximum Cooling Baselines, Ontario, Oregon.

	PEPPER ΔT	VPD	SPEAR ΔT	VPD	MINT ΔT	VPD
1	-1.0	1.90	-1.3	1.91	-1.0	1.90
2	-0.8	1.91	-1.3	1.82	-0.8	1.91
3	-0.8	1.87	-2.0	1.92	-0.8	1.87
4	0.5	1.86	-0.5	2.01	0.5	1.86
5	-2.0	2.49	-2.9	2.85	-2.0	2.49
6	-4.0	2.57	-3.4	2.72	-4.0	2.57
7	-3.8	2.65	-3.7	2.77	-3.8	2.65
8	-4.0	2.82	-3.4	2.55	-4.0	2.82
9	-3.9	2.19	-3.1	2.08	-3.9	2.19
10	-3.4	2.01	-0.5	1.84	-3.4	2.01
11	-4.5	2.05	-2.1	1.79	-4.5	2.05
12	-2.8	1.82	-2.3	1.85	-2.8	1.82
13	-3.6	2.73	-2.5	2.60	-3.6	2.73
14	-3.0	2.64	-3.6	2.76	-3.0	2.64
15	-4.1	2.65	-4.2	2.82	-4.1	2.65
16	-3.7	2.59	-4.4	2.71	-3.7	2.59
17	-5.8	4.88	-5.3	4.67	-5.8	4.88
18	-7.0	5.00	-5.5	4.61	-7.0	5.00
19	-6.5	5.00	-6.1	4.67	-6.5	5.00
20	-6.8	5.04	-6.1	4.84	-6.8	5.04
21					-1.3	1.91
22					-1.3	1.82
23					-2.0	1.92
24					-0.5	2.01
25					-2.9	2.85
26					-3.4	2.72
27					-3.7	2.77
28					-3.4	2.55
29					-3.1	2.08
30					-0.5	1.84
31					-2.1	1.79
32					-2.3	1.85
33					-2.5	2.60
34					-3.6	2.76
35					-4.2	2.82
36					-4.4	2.71
37					-5.3	4.67
38					-5.5	4.61
39					-6.1	4.67
40					-6.1	4.84

Equation: Y= .7733158+-1.47726* X; Correlation:-.8618003
Enter áì to continue, or ESC to quit --

----------Multiple Regression----------

Date/Time 11-21-1989 16:08:00
Data Base Name C:MintCWSI
Description Data base created at 15:12:19 on 11-21-1989

Multiple Regression Report

Dependent Variable: PEPPERΔT

Independent Variable	Parameter Estimate	Stndized Estimate	Standard Error	t-value (b=0)	Prob. Level	Seq. R-Sqr	Simple R-Sqr
Intercept	.6645349	0.0000	.6981179	0.95	0.3538		
VPD	-1.487395	-0.8371	.2290976	-6.49	0.0000	0.7008	0.7008

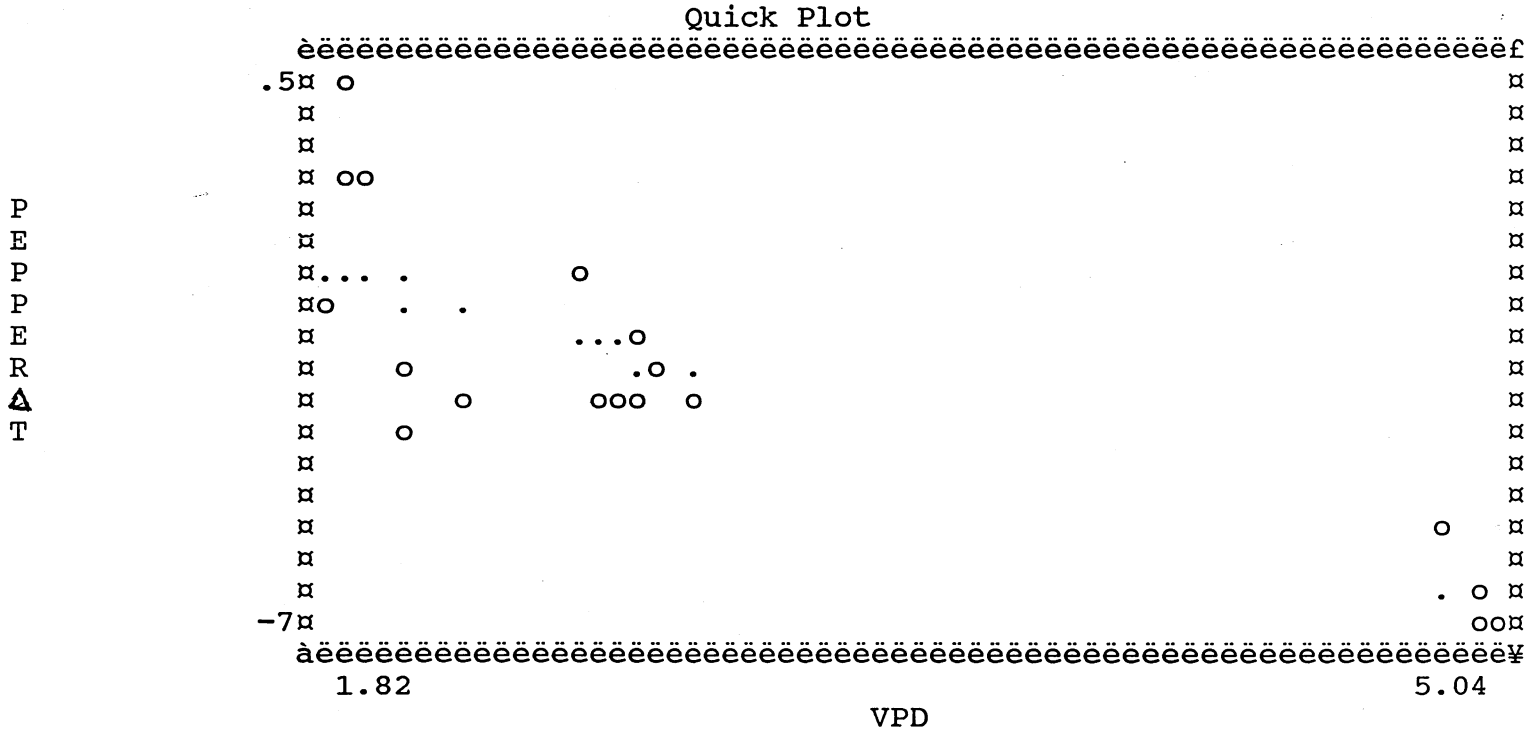
Analysis of Variance Report

Dependent Variable: PEPPERΔT

Source	df	Sums of Squares (Sequential)	Mean Square	F-Ratio	Prob. Level
Constant	1	252.05	252.05		
Model	1	55.61892	55.61892	42.15	0.000
Error	18	23.75108	1.319504		
Total	19	79.37	4.177369		

Root Mean Square Error	1.148697
Mean of Dependent Variable	-3.55
Coefficient of Variation	-.3235766
R Squared	0.7008
Adjusted R Squared	0.6841

Quick Plot



Equation: Y= .6645349+-1.487395* X; Correlation:-.8371111

----------Multiple Regression----------

Date/Time 11-21-1989 16:09:06
Data Base Name C:MintCWSI
Description Data base created at 15:12:19 on 11-21-1989

Multiple Regression Report

Dependent Variable: SPEARΔT

Independent Variable	Parameter Estimate	Stndized Estimate	Standard Error	t-value (b=0)	Prob. Level	Seq. R-Sqr	Simple R-Sqr
Intercept	.8610504	0.0000	.4929856	1.75	0.0977		
VPD	-1.459419	-0.9008	.1658599	-8.80	0.0000	0.8114	0.8114

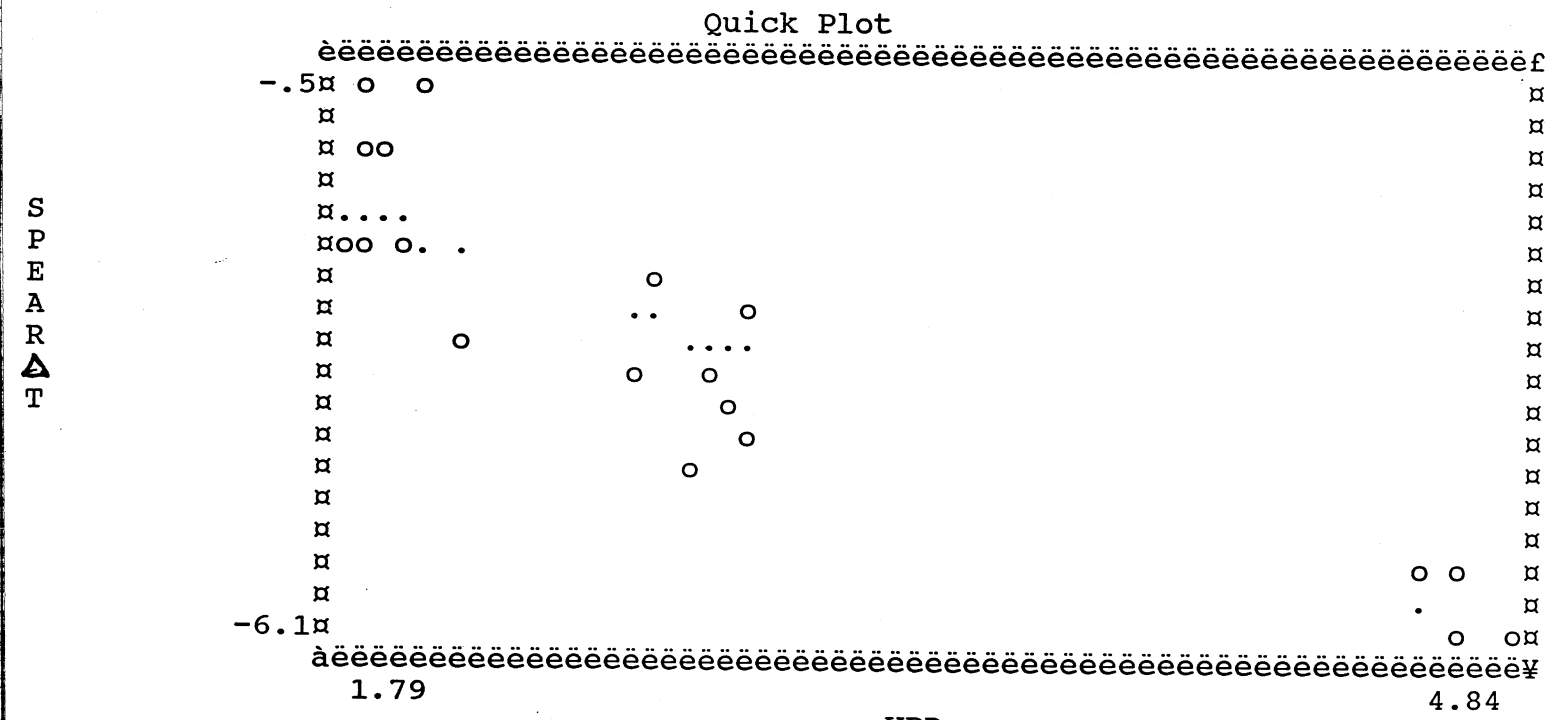
Analysis of Variance Report

Dependent Variable: SPEARΔT

Source	df	Sums of Squares (Sequential)	Mean Square	F-Ratio	Prob. Level
Constant	1	206.082	206.082		
Model	1	44.86708	44.86708	77.42	0.000
Error	18	10.43092	.5794958		
Total	19	55.298	2.910421		

Root Mean Square Error	.7612462
Mean of Dependent Variable	-3.21
Coefficient of Variation	-.2371483
R Squared	0.8114
Adjusted R Squared	0.8009

Quick Plot



Equation: Y= .8610504+-1.459419* X; Correlation:-.9007602

----------Multiple Regression----------

Date/Time 11-21-1989 16:09:52
Data Base Name C:MintCWSI
Description Data base created at 15:12:19 on 11-21-1989

Multiple Regression Report

Dependent Variable: C5 Mint ΔT

Independent Variable	Parameter Estimate	Stndized Estimate	Standard Error	t-value (b=0)	Prob. Level	Seq. R-Sqr	Simple R-Sqr
Intercept	.7733159	0.0000	.4245671	1.82	0.0764		
C6 VPD	-1.47726	-0.8618	.1410518	-10.47	0.0000	0.7427	0.7427

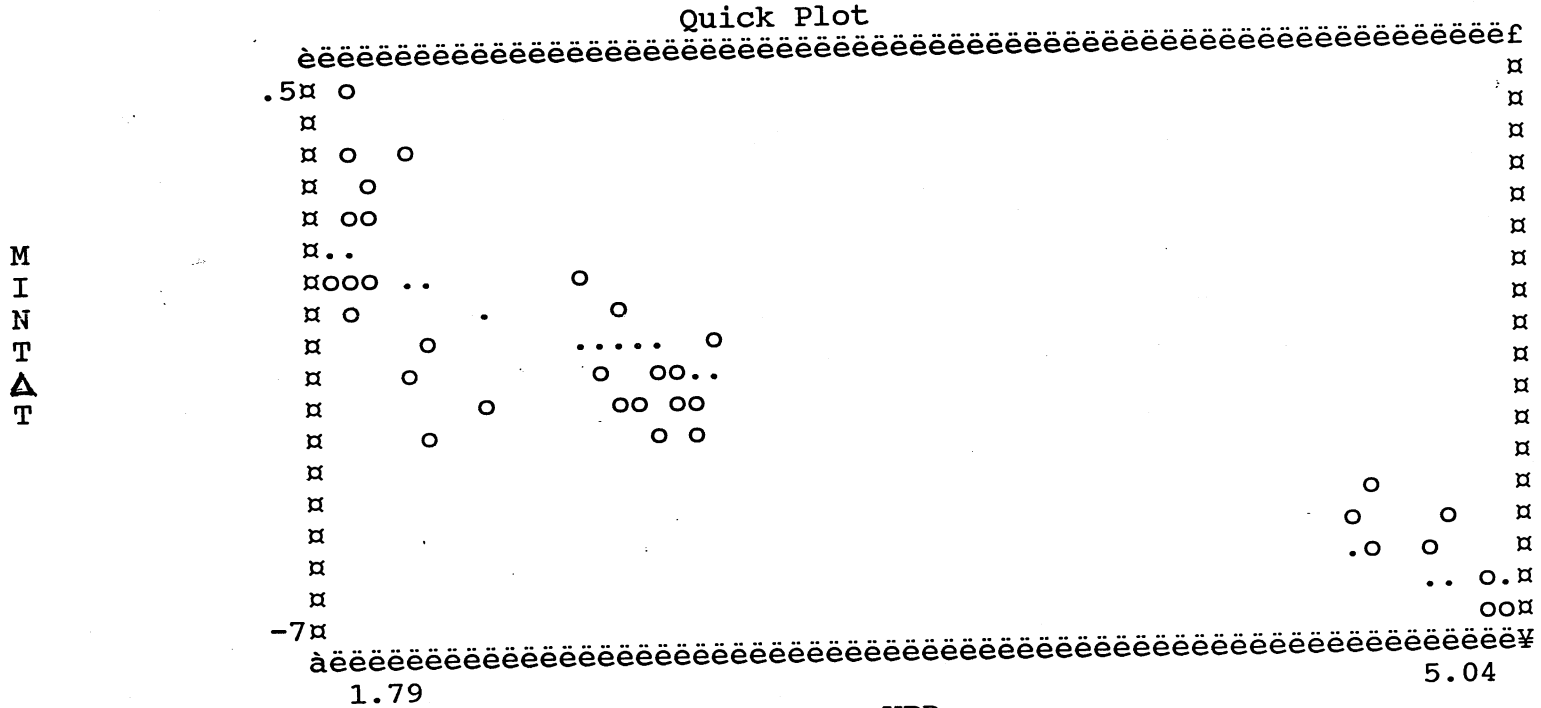
Analysis of Variance Report

Dependent Variable: C5 Mint ΔT

Source	df	Sums of Squares (Sequential)	Mean Square	F-Ratio	Prob. Level
Constant	1	456.976	456.976		
Model	1	100.8765	100.8765	109.69	0.000
Error	38	34.94754	.9196722		
Total	39	135.824	3.482667		

Root Mean Square Error	.9589954
Mean of Dependent Variable	-3.38
Coefficient of Variation	-.2837265
R Squared	0.7427
Adjusted R Squared	0.7359

Quick Plot



Equation: Y= .7733158+-1.47726* X; Correlation:-.8618003

HOW TO CALIBRATE SCHEDULER BASELINES

All Purpose Baselines

One recurring question is "How do I use the Scheduler on crops for which no baselines are available?" In response to this question, we have developed two "all-purpose" baselines. They are labelled as either "high" or "low." The "high" index is most appropriate for use with leafy agricultural crops such as corn, cotton, tomatoes, etc. and many tree crops. The "low" index is most appropriate for crops with relatively low transpiration rates. It is up to the user to decide which index is most appropriate for his crop. These baselines have been given a unique, proprietary form which allows them to respond properly as long as the sun is shining brightly. The same general restraints concerning sampling time, sampling technique, etc., also apply to these baselines as apply to the standard baselines.

In order to use these baselines properly, it is necessary to calibrate the response of a crop. This is done with a series of user conducted tests. A user should compare the response of an all-purpose index with a "stressed" and "non-stressed" area. The stressed area should have as severe a stress as possible without killing the crop. This comparison provides the user with the upper and lower limit of crop response. A periodic re-calibration of the scale is recommended since large changes in ambient temperatures (very cool to very hot) or physical changes in the crop may affect the calibration point.

For example, suppose a grower of corn used the low baseline instead of the baseline programmed in the Scheduler. He may find that the range of the index response is between -10.0 and +5.0, with non-stressed readings generally around -4.0 to 0.0, and most severely stressed readings around 5.0. The user would feel good in assuming that index values much in excess of 0.0 indicate stress, and that index values of 3 or more are to be avoided entirely. This simple calibration approach also applies to the standard baselines.

Standard Baselines

Each Scheduler comes programmed with a user selected group of baselines. Through our own research, we have defined these baselines for each crop as precisely as possible. One question which frequently surfaces is "What about varietal differences in baselines?" Another is "How do the baselines change throughout a season?" It is clear that it is possible to construct an infinite number of baselines. To simplify matters and make the Scheduler a practical tool, the best approach to take when researching such questions as varietal response differences is to determine how the varieties differ with respect to a standard baseline.

For example, assume a researcher wants to determine if significant stress patterns exist between 10 hybrids of corn. He finds that there are differences. How to express the results is his problem. With one approach, he could list ten different baselines. With another approach, he could list the percent difference of each hybrid from the Scheduler baseline. Growers using these hybrids would then know how to adjust their Scheduler readings for each hybrid.

We have taken great care to make each Scheduler unit as technically accurate and durable as possible. Any sensor (the Scheduler has four) can potentially change as it ages. We believe these changes will be minimal for all sensors except the humidity sensor, which may need to be changed every one to two years. Although the absolute accuracy of a sensor may change with time, the Scheduler index readings do not become invalid. A slow drift in sensor calibration results in a slow change in the response scale of the index. By periodically calibrating a standard index to a crop (as described above), the user should find that he can use the Scheduler effectively for many years to come.

APPLICATION NOTE

USING THE SCHEDULER PLANT STRESS MONITOR ON ROW CROPS

I. General

The general procedures for using the Scheduler are the same for all row crops. This note summarizes these procedures and makes comments related to specific crops.

A young row crop, such as corn, sorghum, or soybeans begins with the emergence of the seedlings which are spaced several inches apart within a row in row spacings of typically about 30 inches. The size of these seedlings make it impossible to use the Scheduler effectively for at least the first one to two weeks after emergence. Individual plant leaves or leaf clusters must be at least two inches in width.

When emerging leaves achieve a diameter of two inches, there is a great deal of soil still exposed, regardless of whether a user is aiming the Scheduler down a row or across a row. This means that only individual leaves, leaf clusters, or leaf whorles may be effectively sampled. This sampling is accomplished by aiming at the individual leaf from a distance of two to three inches.

It is important to remember that young plants do not have a well-developed root system. These plants are also exposed to soil temperatures which can be extremely high. Therefore, the normal expected stress index for young plants is higher than that for plants after ground cover is nearly complete. For example, a stress index of three to four at 40 percent ground cover may be normal, but would indicate stress at 100 percent ground cover. One way of interpreting this behavior is to say that the normal state of young plants is to be somewhat stressed.

Sampling individual leaves is still much faster than neutron probe or tensiometer readings. The Scheduler can sample an individual leaf in one-fourth of a second. Each sample roughly corresponds to the area measured by a single tensiometer, soil moisture block, or pressure bomb measurement. Within a few seconds, more area can be sampled with the Scheduler than would be practical with these other devices.

Once a row crop reaches about 50 percent ground cover, it is possible to "shoot" across the rows and not view a significant amount of soil. Remember, the infrared gun sees approximately what your eyes see. If you see soil, so does the Scheduler. It is of paramount importance that only green, sunlit vegetation be sampled.

Some researchers prefer to aim the Scheduler down a row, since researchers often put different treatments on adjacent rows. When aiming down a row (instead of across a row) it is important to be sure that (1) the plants are wider than the field of view of the infrared thermometer, and (2) only sunlit leaves are viewed. Row crops have a "sunny" side and a "shaded" side. Always view the sunny side of a row.

The general guidelines for row crops are:

1. Early in the season, measure only individual leaves or groups of leaves. Avoid any soil in the measurement.
2. Always limit samples to sunlit leaves and the sunny side of a row.
3. Always take a minimum of 20 samples, unless the uniformity (consistency) of the readings is very high.
4. Once ground cover exceeds 50-75 percent, a user can begin "scanning" a field from designated positions, or while walking through the field.

II. Specific Crops

Grain Sorghum

Prior to headings, sorghum is sampled the same as other row crops. Grain sorghum has a distinct seed bearing head which emerges after the vegetative period. This head creates a partial barrier for the Scheduler. Effective readings can still be made, however, if individual plants and leaves are sampled. Researchers at the University of Nebraska have been able to detect significant temperature differences between stressed and non-stressed sorghum from a height of about six feet above the top of the crop. When viewed from this height, fully emerged heads appear to compose about 30 percent of the scene viewed by the Scheduler. Clearly, sufficient vegetation can still be viewed to detect differences between stressed and non-stressed areas, but the effect of the heads on the stress index is uncertain.

We recommend that for use on sorghum, individual plants and leaves be sampled. If measurements above the crop are made (for instance, from a ladder), then the maximum effective distance is limited to about 60 feet.

Grapes

Researchers at Fresno State University have found that by viewing leaves on the sunny side of a row they could use the Scheduler. When emerging leaves are small, individual leaves must be sampled. As the vine gets bigger, the leaves can be sampled by standing on a short ladder and aiming down the center of the vine, or while walking along the sunny side. Care must be taken to avoid shadows. It is possible to "shoot" across rows, depending on the type of trellises used for the vines. In general, a user should plan on sampling one vine at a time. The sunny side of a vine can often be viewed at a "glancing" angle for a distance of 10-20 feet. It is important to be consistent with sampling techniques.